High-Speed Ground Transportation for America

U. S. Department of Transportation
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Main Report

High-Speed Ground Transportation for America

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CHAPTER 1
BACKGROUND

This report examines the economics of bringing high-speed ground transportation (HSGT) to well-populated groups of cities throughout the United States. The intention is to draw nationwide—not corridor-specific—conclusions from projections of the likely investment needs, operating performance, and benefits of HSGT in a set of illustrative corridors in several regions. Although useful collectively, these case studies cannot substitute for the more detailed, State- and privately-sponsored analyses of specific corridors that would be prerequisite to HSGT implementation.

Congressional interest in HSGT dates back at least to 1965, with the passage of the High Speed Ground Transportation Act. This legislation, initially authorized at $90 million, started a Federal effort to develop, and demonstrate where possible, contemporary and advanced HSGT technologies. Under the HSGT Act, the Office of High-Speed Ground Transportation of the Federal Railroad Administration (FRA) introduced modern HSGT to America in 1969 by deploying the self-propelled Metroliner cars and the Turbotrain in Northeast Corridor revenue service. Simultaneously, the construction of new suburban rail stations at Metropark (Iselin), New Jersey, and Capital Beltway (Lanham), Maryland significantly improved access to the new HSGT service. Although catalyzed by the Federal Government, these Washington—New York—Boston service improvements represented a private/public partnership between the freight railroad companies, the equipment suppliers, States, localities, and the FRA.[1] The HSGT program also included a comprehensive multimodal transportation planning effort focusing on long-term needs in the Northeast Corridor "megalopolis,"[2] as well as a pioneering research and development program in such advanced technologies as tracked air-cushion vehicles, linear electric motors, and magnetic levitation (Maglev) systems.

The Rail Passenger Service Act of 1970 led to the creation of the National Railroad Passenger Corporation (Amtrak) in 1971 as a way of ensuring continued operation of an intercity rail passenger network in the United States. On May 1, 1971, Amtrak took over from the freight railroads the responsibility for operating intercity rail service in most of the United States, including the Northeast Corridor.

The research, planning, development, and demonstration efforts under the HSGT Act converged to recommend improved high-speed rail in the Northeast Corridor as the optimal response to steadily increasing congestion and decreasing service quality in the

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[1] Walter Shapiro, "The Seven Secrets of the Metroliner's Success," *The Washington Monthly*, March 1973, pp. 7 ff.
[2] So termed by Senator Claiborne Pell in his book Megalopolis Unbound.

other intercity modes.[3] While the Metroliners and Turbotrain had demonstrated the potential of HSGT, the Boston-Washington route infrastructure was still suffering from decades of deferred maintenance. Thus, when HSGT Act appropriations ended in 1975, the focus of Congressional efforts shifted to upgrading the Northeast Corridor infrastructure with the objective of enhancing reliability and allowing shorter trip times, particularly between New York City and Washington, D.C. Pursuant to Title VII of the Railroad Revitalization and Regulatory Reform Act of 1976,[4] a total of $3.3 billion[5] has been appropriated to date for the Northeast Corridor Improvement Project (NECIP), a massive engineering and construction effort which has improved major sections of the main line by means of track reconstruction, new signal and control systems, elimination of many highway/railroad grade crossings, construction of maintenance-of-way bases and maintenance-of-equipment facilities, improvements to stations, and bridge replacement and repair. In addition to providing the foundation for a reliable HSGT intercity service in the Northeast, the NECIP has also benefited commuter rail operators by effectively increasing the operating flexibility of the Northeast Corridor. The marketplace success of HSGT in the Northeast endures as the legacy of these early Federal HSGT efforts[6] and has encouraged ongoing efforts to achieve analogous service standards between Boston and New York City.

Federal HSGT emphasis in the 1980's shifted to studies of potential HSGT corridors. Among those efforts was a series of reports on "Emerging Corridors," developed in conjunction with Amtrak, which were issued in 1980 and 1981. In 1984, grants of $4 million were set aside for HSGT corridor studies on the State level under the Passenger Railroad Rebuilding Act of 1980.[7] The law included authority for engineering and design studies. This program funded about seven major HSGT analyses in various corridors.

As Federal involvement in HSGT planning continued during the 1980's, State involvement also increased. By 1986, at least six States had formed high-speed rail entities, and ultimately Florida, Ohio, Texas, California, and Nevada awarded franchises to private-sector consortia to build and operate intercity high-speed rail or Maglev systems. For a variety of reasons, none of these proposals has yet led to construction. Learning from such challenges, the States have persisted in—and in some cases redoubled—their HSGT efforts. Exemplifying this growing State interest in HSGT technologies is New York, which in the 1980's invested heavily in upgrading the New York City—Albany portion of the Empire Corridor to 110 mph (with some Federal funding assistance) and which recently undertook an intensive equipment demonstration program. Today, more than 15 States have passed

[3] U.S. Department of Transportation, *Improved High-Speed Rail in the Northeast Corridor,* 1973.
[4]45 U.S.C. 851 et seq.
[5] *Amtrak's Northeast Corridor: Information on the Status and Cost of Needed Improvements,* General Accounting Office, Washington, DC, GAO/T-RECD-95-151BR, April 13, 1995, p. 24.
[6] Amtrak's services carry 45% of the combined air-rail traffic in the New York-Washington city pair, according to Amtrak's *1994 Annual Report*, p. 4.
[7]Pub. L. 96-254

enabling legislation facilitating HSGT activities. Some States, moreover, are attempting to implement HSGT, as exemplified by Florida's recent selection of—and continuing cooperation with—Florida Overland Express as its private partner in the Miami—Orlando—Tampa corridor development.

In the late 1980's, Congress sought further information on Maglev, requesting FRA to assess the potential for Maglev technology and systems in the United States.[8] Accordingly, FRA submitted a preliminary Maglev report to Congress[9] in June 1990. In 1991, the National Maglev Initiative (NMI) was launched,[10] with an initial appropriation of $12 million. The NMI was a cooperative effort among the Department of Transportation, the U.S. Army Corps of Engineers, and the Department of Energy, directed at system concepts for Maglev development, market analysis, and safety issues.[11]

A key element of Congressional interest in HSGT has been to ensure the safety of new technologies. The Rail Safety Improvement Act of 1988[12] extended the statutory definition of "railroad" in the Federal Railroad Safety Act of 1920 to include "all forms of non-highway ground transportation that runs on rails or electromagnetic guideways," including "high-speed ground transportation systems that connect metropolitan areas, without regard to whether they use new technologies not associated with traditional railroads." In response to this direction, FRA examined a variety of safety issues—including collision avoidance and accident survivability, biological effects of Maglev magnetic field exposures, and fire safety—to determine required regulatory activity with respect to HSGT safety. Technical reports have been issued on these subjects.[13] FRA has also entered into several study agreements with other national governments to exchange information concerning HSGT safety systems.

In 1991 the Senate passed a High-Speed Rail Transportation Act[14] that would have encouraged research, development, design, and implementation of Maglev and other HSGT

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[8]As directed by the conference report accompanying the FY 1989 Department of Transportation and Related Agencies Appropriations Act (H. R. Rept. No. 957, 100th Cong.(1988)).
[9]U.S. Department of Transportation, *Assessment of the Potential for Magnetic Levitation Transportation Systems in the United States,* June 1990.
[10]Also in 1991, the Office of Technology Assessment issued a study of Maglev and tiltrotor technology, entitled New Ways, which discussed funding issues and options.
[11]The NMI also received direction from a Transportation Research Board "Committee for the Critique of the Federal Research Program on Magnetic Levitation Systems." Cf. FRA, U.S. Army Corps of Engineers, and U.S. Department of Energy, *Final Report on the National Maglev Initiative,* September 1993.
[12]49 U.S.C. 20102
[13] Among the reports covering HSGT safety are *Safety of High Speed Guided Ground Transportation Systems*-Four Volumes, U.S. Department of Transportation, Federal Railroad Administration, DOT-VNTSC-FRA-93-2, March 1993; *Safety of High Speed Magnetic Levitation Transportation Systems*, U.S. Department of Transportation, Federal Railroad Administration, DOT-VNTSC-FRA-93-10, September 1993; and *An Assessment of High-Speed Rail Safety Issues and Research Needs*, U.S. Department of Transportation, Federal Railroad Administration, DOT/FRA/ORD-90/04, May 1990.
[14]S.811

technologies in the United States and would have promoted domestic manufacturing efforts. The bill also required a study of HSGT commercial feasibility, evaluation of potential domestic Maglev designs which could be used in development of a full-scale prototype, and adoption of a national high-speed rail policy.

Key provisions of the proposed High-Speed Rail Transportation Act were ultimately incorporated into the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA),[15] which mandated this study.[16] Section 1036 of ISTEA[17] authorized a National High-Speed Ground Transportation Program at $800 million, including $725 million for development of a U.S.-designed Maglev prototype, $50 million for demonstration of new HSGT technologies, and $25 million for research and development. Funding for development of a Maglev prototype has not been requested by the Executive Branch or appropriated by Congress and remaining authorizations for the Maglev prototype have been rescinded. Similarly, although ISTEA amended the Railroad Revitalization and Regulatory Reform Act of 1976 to authorize up to $1 billion in government-guaranteed loans to help finance construction of high-speed rail systems, no such loan program has received appropriations.

Separately, section 1010 of ISTEA[18] authorized the designation of five high-speed rail corridors by the Secretary of Transportation, and provided $30 million for the elimination of highway/rail grade crossings in these corridors.[19] To date the funds have been used on grade crossing projects in California, Florida, Illinois, Indiana, Michigan, North Carolina, Oregon, Virginia, Washington, and Wisconsin. The Swift Rail Development Act, which was enacted into law in November 1994 with Executive Branch support, authorized $184 million for FY 1995 through FY 1997 for corridor planning and technology improvements.[20]

This study may therefore be viewed as a continuation of many years of Congressional, Executive Branch, State, local, and private interest in the development of HSGT technologies and services. The study also lays the groundwork for HSGT policy and

[15] P.L. 102-240, 105 Stat. 1914
[16] 49 U.S.C. 309d
[17] 105 Stat. 1978
[18] 105 Stat. 1934
[19] Further definition of these Section 1010 corridors appears in Chapter 3, where they are presented as illustrative corridors in this study.
[20] For FY 1995, $17.5 million was appropriated for technology improvements only; State planning funds were not appropriated. For FYs 1996 and 1997, appropriations were as shown in the following table (amounts are in millions of dollars):

Fiscal Year	State Planning	Technology Improvements	Administration	Total
1996	$1.25	$22.50	$0.38	$24.13
1997	$1.25	$24.45	$0.48	$26.18

may assist State and local governments, private firms, and others as they weigh further efforts towards implementing HSGT in the United States.

CHAPTER 2
HSGT IN ITS INTERMODAL CONTEXT

This chapter defines HSGT and explains why it merits consideration as a viable passenger transport option in congested intercity corridors.

DEFINITION OF HSGT

HSGT is self-guided intercity passenger ground transportation—by steel-wheel railroad or magnetic levitation (Maglev)—that is time-competitive with air and/or auto for travel markets in the approximate range of 100 to 500 miles.[1] A **market** is a city-pair—two metropolitan areas, such as New York City and Washington, D.C.; a **corridor** is a natural grouping of metropolitan areas and markets that, by their proximity and configuration, lend themselves to efficient service by ground transportation.

This is a market-driven, performance-based definition of HSGT. It recognizes that total trip time (including access to and from stations), rather than speed *per se*, influences passengers' choices among transport options in a given market; and that travelers evaluate each mode not in isolation, but in relation to the performance of the other available choices.[2] A specific technological option may constitute HSGT in a corridor 185 miles in length, yet may fall far short of HSGT status in a 400-mile corridor. Conversely, another option might suit a longer corridor admirably but represent an ineffective expenditure of public funds in a much shorter corridor. Moreover, raising top speeds in a corridor may provide only one of many ways to reduce trip times but may not be the most cost-effective way.[3]

IMPETUS FOR HSGT

HSGT activity in the United States will only occur because of pressing transportation needs. As travel demand grows, intercity transportation by air and auto increasingly suffers from congestion and delay, particularly within metropolitan areas; at and surrounding airports; and during weekend, holiday, and bad-weather periods. This declining quality of service adversely affects intercity travelers, other transport system

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[1] A few examples of HSGT service around the world include the Shinkansen in Japan; the TGV in France; the ICE and planned Berlin—Hamburg Maglev in Germany; and in the United States, Amtrak's Metroliners between New York and Washington. Important HSGT services exist in other countries as well.
[2] Trip time represents but one of the many criteria used by travelers in choosing among modes, as described in National Analysts, Inc. for FRA, *The Needs and Desires of Travelers in the Northeast Corridor: A Survey of the Dynamics of Mode Choice Decisions*, NTIS publication PB 191 027, February 1970. Other criteria defining the transportation product include fares (perceived costs for auto), frequency, and service quality. See the discussion of demand and diversions in Chapter 5.
[3] Cf. Transportation Research Board, *In Pursuit of Speed*, pp. 89, 90, and 97.

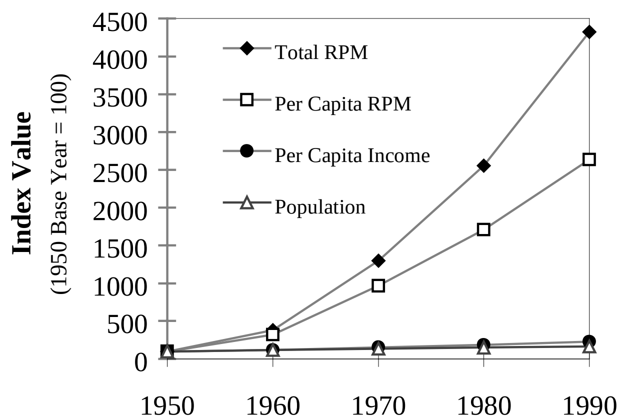
users, carriers, and the general public, and provides the impetus for careful evaluation of HSGT options.

The following sections explicate those needs by examining nationwide trends in the air and highway modes.

Air Transportation

Domestic intercity air travel has grown much faster than population and income since 1950, as demonstrated in Figure Chapter 2 -1. The relatively high growth in air travel from 1950 to 1970 reflects in part the substitution of air travel for the formerly ubiquitous intercity rail travel. In recent decades, the discrepancies among air passenger, population, and income growth rates have diminished (see Figure Chapter 2 - 2). This trend stems from the maturation of the air travel industry, the acclimation of entire generations to flight as an everyday occurrence, and the decline in the price of air travel in real terms from the 1970s to today.[5] The Federal Aviation Administration (FAA) has projected domestic air carrier revenue passenger miles (RPM) and passenger enplanements to increase at an average annual rate of 3.7 and 3.5 percent, respectively, between 1993 and 2005.[6] These increases assume higher load factors, greater seating capacity in aircraft, and longer passenger trip lengths. Over the same period, RPM and passenger enplanements for international air carriers are forecast to increase at an average annual rate of 6.3 and 6.5 percent respectively. For regional/commuter airlines, RPM are expected to grow at 8.5 and 6.9 percent annually on average.[7]

Figure Chapter 2 -1
Domestic Air Travel: Long-Term Trends in Revenue Passenger-Miles (RPM), Population, and Income[4]



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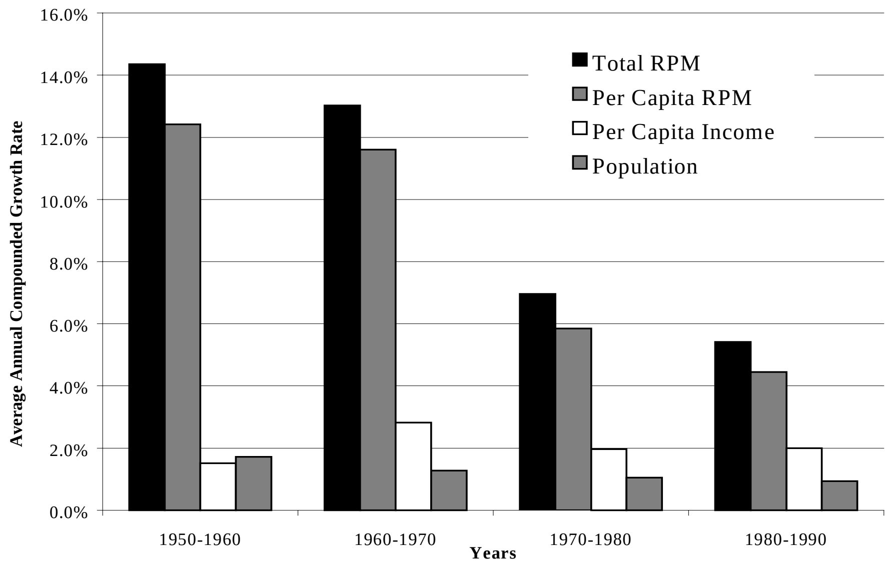
[4] U.S. Bureau of the Census, *Statistical Abstract of the United States: 1994*, 114th ed., pp. 8, 451.
[5] The revenue per passenger mile in constant 1993 dollars declined from an average of 21 cents in the years 1968 to 1971 to an average yield of 13 cents per mile in 1993. Contributing to this trend has been the emergence of such low-cost regional carriers as Southwest Airlines. Federal Aviation Administration, *FAA Aviation Forecasts Fiscal Years 1994-2005*, FAA-APO-94-1 (March 1994), p. III-25.
[6] Ibid., pp. I-7.
[7] Ibid., p. I-8, 9.

Figure Chapter 2 -2
Air Travel Comparisons —
Average Annual Compounded Growth Rates by Decade[8]



Beyond 2005, increases in population and income are expected to result in long-term growth for air travel. Generally, however, air travel is forecast to increase faster over the next ten years than in the longer term because the growth rates of population and income are declining and are expected to continue to do so. For the period 2005 to 2020, the FAA published a forecast that is more limited in scope than its short-term forecast and that omits any prediction for domestic RPM. It does, however, predict that domestic air carrier enplanements will increase at an annual average rate of 2.5 percent from 2005 to 2020,[9] lower than the 3.5 percent growth forecast for 1993 to 2005 (but still substantial in view of existing capacity constraints). That assumption agrees with an assumed drop in the growth rate for national income.[10]

Over the past decades, the expansion of air traffic has far outpaced the growth in airport capacity. As demonstrated in Figure Chapter 2 -3, existing airport congestion has created perceptible delays; the FAA now regards 23 airports, each exceeding a threshold of 20,000 airline flight delay-hours per year, as "delay problem" locations, and projects that

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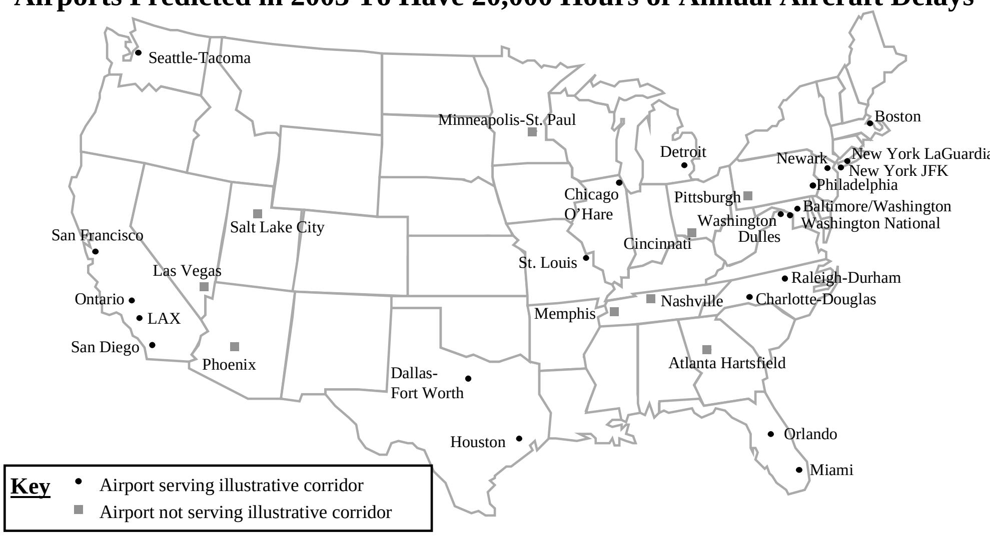
[8] U.S. Bureau of the Census, *loc. cit.*
[9] Federal Aviation Administration, *FAA Long-Range Aviation Forecasts: Fiscal Years 2005-2020*, FAA-APO-94-7, July 1994, p. 2.
[10] Chapter 4 compares and contrasts the FAA forecasts with those for this report.

32 airports will exceed the threshold by the year 2003 unless capacity is increased.[11] However, the FAA is investing significantly to improve airport capacity.

Figure Chapter 2 -3
Airports Predicted in 2003 To Have 20,000 Hours of Annual Aircraft Delays[12]



Aircraft delay creates significant cost penalties. The FAA has calculated the average aircraft operating cost to be $1,587 per hour based on a range of $42 per hour for small single-engine planes to $4,575 per hour for large aircraft. With this information the FAA determined that an airport incurring 20,000 hours of annual delay will cause delay costs of at least $32 million.[13] Other costs include the environmental effects (e.g., noise and emissions) of aircraft delays and the effects on passengers who suffer the consequences of missing work, meetings, connections, and business opportunities. These costs—affecting air carriers and passengers alike—significantly influence the benefit/cost analysis (Chapter 6).

In the face of increasing air traffic, delays and costs, many states and localities must decide whether and how much to invest in airport expansion to reverse—or at least alleviate—deterioration in the quality of air service. The FAA has identified and recommended actions to prevent the projected growth in delays. The recommended improvements include new technology to optimize existing airport capacity, terminal air space procedures, and en route airspace capacity. The FAA considers that the largest capacity gains come from building new airports and new or extended runways at existing

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[11]Federal Aviation Administration, *1994 Aviation Capacity Enhancement Plan*, Report No. DOT/FAA/ASC-94-1, October 1994, p. 1-1.
[12] Ibid., p. 1-17.
[13] Ibid., p. 1-1.

airports. To increase capacity, 15 of the 23 delay-problem airports identified in 1993 are planning or constructing new or extended runways; 24 of the 32 delay-problem airports foreseen for 2003 have similar expansion programs as well. In total, at the Nation's top 100 airports, the anticipated cost of adding planned and proposed runway capacity exceeds $9.0 billion.[14]

The FAA's National Plan of Integrated Airport Systems predicts that—if the recommended improvements are effected—capacity at most of the 29 "large hub" commercial service airports in the United States would adequately meet the forecast in demand.

Weather conditions consistently account for over 50 percent of aircraft delays of 15 minutes or more (72 percent in 1993). The FAA therefore proposes technology improvements for new electronic guidance and control equipment to allow for two or three flight arrival streams instead of one or two during periods of poor visibility.[15]

At some problem airports, primarily the large metropolitan area airports on the East and West Coasts, the FAA has determined that recommended improvements alone would not adequately meet the projected growth in demand. The FAA does, however, point out other potential solutions to the aviation system capacity problem. Characterized as "marketplace solutions" because they rely on competitive free-market influences, these solutions also depend on the interest and participation of aviation and transportation industry groups and various governmental organizations. These marketplace solutions could include[16]:

- expansion of smaller regional/commuter carriers;
- emergence of tiltrotor aircraft technology[17];
- development of a next generation of aircraft with seating capacity of 500 to 800;
- enhancement of reliever and general aviation airport systems;
- advances in telecommunications;
- intermodalism; and
- development of HSGT.

The FAA considers HSGT to be a potential means of relieving the pressure on short-haul air traffic by diverting air trips of 500 miles or less.[18] In addition, the FAA

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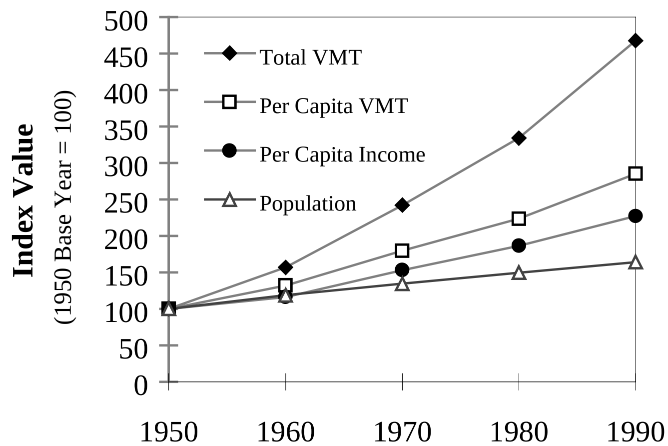
[14] Ibid., p. 2-11.
[15] Ibid., p. 1-13 and chapter 5.
[16] Ibid., chapter 6.
[17] Tiltrotor is the subject of a recent study: Civil Tiltrotor Development Advisory Committee, *Report to Congress in Accordance with PL 102-581*, December 1995.

points out that intercity HSGT systems can be designed for immediate access to airports, with rail stations inside air passenger terminals, and that HSGT could provide connections between multiple airports in large metropolitan areas. These intermodal concepts have influenced the design and evaluation of the HSGT systems assumed for this study.[19] For example, Figure Chapter 2 -3 demonstrates that the illustrative corridors in the study (identified in Chapter 3) serve most of the metropolitan areas experiencing severe air traffic delays. Moreover, the HSGT corridors include station sites at airports wherever practicable.

Highway Transportation

Figure Chapter 2 -4
Automobile Travel: Long-Term Trends in Vehicle-Miles Traveled (VMT), Population, and Income[20]



The growth in per capita vehicle-miles traveled (VMT), like that of RPM for air travel, showed particular strength in the 1950's and 60's. These decades saw the decline of U.S. rail passenger service as well as marked growth in automobile ownership, per capita income, and general living standards (See Figure Chapter 2 -4 and Figure Chapter 2 -5). More recently, for the eight-year period from 1983 to 1991, total highway travel increased at an annual rate of 3.5 percent,[21] while population grew at approximately only 1 percent.[22] Growth in urban travel outpaced rural travel at 3.9 percent per year versus 2.9 percent.[23] Overall vehicle travel increased by 32 percent between 1983

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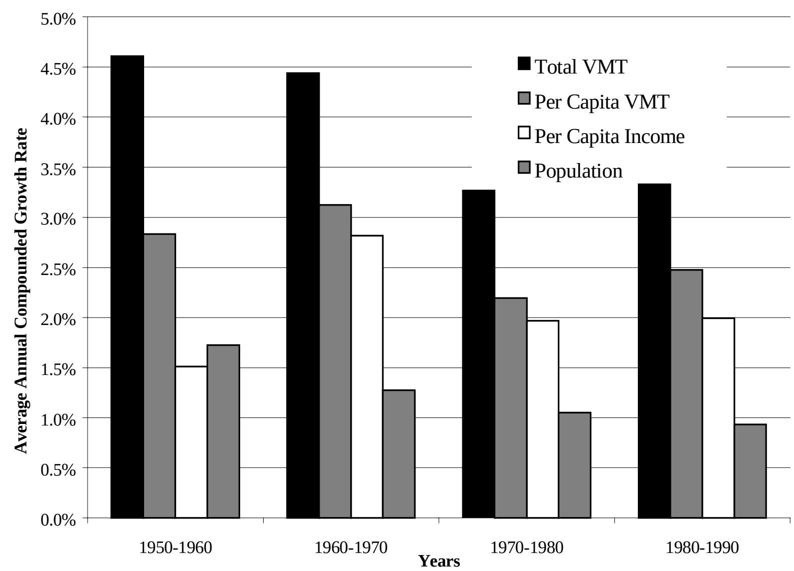
[18] Federal Aviation Administration, *1994 Aviation Capacity Enhancement Plan*, p. 6-18
[19] See Chapter 4 for particulars.
[20] U.S. Bureau of the Census, *Statistical Abstract of the United States: 1994*, pp. 8, 451; Federal Highway Administration, *Highway Statistics: Summary to 1985*, p. 225; U.S. Department of Transportation, Bureau of Transportation Statistics, *National Transportation Statistics: Historical Compendium, 1960-1992*, September 1993, p. 20.
[21] Report of the Secretary of Transportation to the U.S. Congress, *The Status of the Nation's Highways, Bridges, and Transit Conditions and Performance*, 1993, p 19.
[22] U.S. Bureau of the Census, *op. cit.*, p. 8.
[23] Report of the Secretary of Transportation, *loc. cit.*

and 1991 measured by the change in rural and urban VMT.[24] This growth reflects increases in vehicle trip length, population, and person-trips per capita, a reduction in vehicle occupancy, and mode shifts to single occupant vehicles.

Figure Chapter 2 -5
Automobile Travel Comparisons –
Average Annual Compounded Growth Rates by Decade[25]



The Federal Highway Administration (FHWA) forecasts that the average annual rate of growth in overall highway travel will decline from historical levels. Traditionally, highway travel growth has exceeded 3.0 percent annually since 1945. In a departure from past trends, FHWA forecasts that for the 20-year period from 1992-2011, overall highway travel will only grow at an average rate of 2.5 percent per year, for a total increase of about 65 percent.[26] This forecast is based on FHWA assumptions that mass transit usage will increase at an aggressive rate in substitution for highways.[27]

The FHWA's analyses suggest that highway system performance will deteriorate through 2011 in the Nation's 33 urbanized areas with population greater than one million, as well as in some smaller urbanized areas. This reflects a comparison of current and expected highway expenditures with amounts needed to fund the maintenance and

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[24] Ibid., pp. 37-38.
[25] U.S. Bureau of the Census, *op. cit.,* pp. 8, 451; Federal Highway Administration, *Highway Statistics: Summary to 1985*, p. 225; U.S. Department of Transportation, Bureau of Transportation Statistics, *National Transportation Statistics: Historical Compendium, 1960-1992*, September 1993, p. 20.
[26] Report of the Secretary of Transportation., p. 149.
[27] Ibid., p. 155.

improvements required to accommodate projected demand.[28] Actual congestion statistics, particularly for urban areas, illuminate the trend of deteriorating performance. For example, on urban highways on the Interstate System, the percentage of peak-hour travel that occurred under congested conditions exceeded 70 percent in 1991, compared to 55 percent in 1983. On other urban freeways and expressways, the percentage of congested peak-hour travel rose from 49 percent in 1989 to over 61 percent in 1991. Of total urban peak-hour congestion, 65 percent occurred in the 33 urban areas with populations of over one million.[29] Peak hour congestion more than doubled from 1983 to 1991 on rural interstates, which are comparatively less prone to bottlenecks. Therefore, current and anticipated demand will tax the highway system's ability to maintain existing levels of mobility.

The costs of highway congestion include delay, increased travel time, increased fuel consumption, increased vehicle emissions and reduced air quality, increased cost of goods transported resulting in increased costs to the consumer, and increased aggravation to the driver. A report by the Texas Transportation Institute states that in 1991, the total cost of congestion for 50 urban areas studied was approximately $42.3 billion, with delay accounting for approximately 89 percent of this amount, and excess fuel consumption for the remainder.[30]

Some potential approaches to alleviating the rate of growth in highway congestion include:

- construction of additional lane-miles and new highways;
- application of congestion pricing to highway use, perhaps through electronic toll collection;
- implementation of intelligent vehicle-highway systems—also known as intelligent transportation systems—now under development by the FHWA; and
- provision of intracity and intercity alternatives to the automobile that promise to attract significant traffic.

Summary: The Intermodal Context

America's air and highway transportation systems are experiencing increasing congestion. Preservation of service quality for those modes will entail significant investment. Meanwhile, HSGT represents a family of transportation options that may be found to offer social, economic, and environmental benefits in specific applications,

[28] Ibid., pp. 171 and 174.
[29] Ibid., p. 85.

although the required public and private investment would be substantial. Thus, the question before the States and localities ultimately reduces to this: **Given the need to preserve and improve travel mobility, and given the available options, what <u>combination</u> of approaches would be most suitable, and how might each mode bring its inherent advantages to bear in such a combination?**

With respect to HSGT, this report will assist States, localities, and the general public in answering that question.

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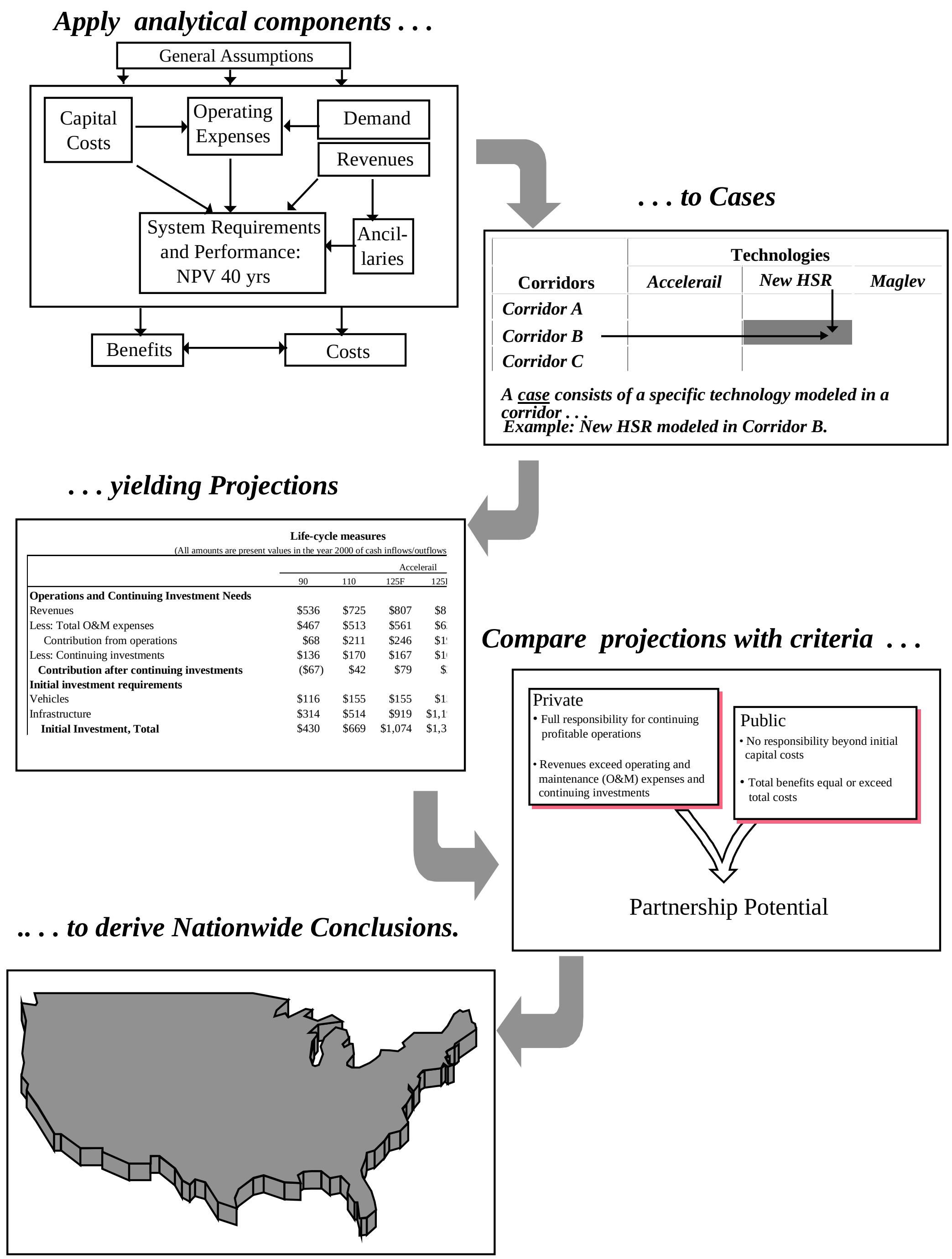
[30] Texas Transportation Institute, *Trends in Urban Roadway Congestion—1982 to 1991*, Vol. 1: Annual Report, Research Report 1131-6, Austin: September 1994, p. 32.

CHAPTER 3
ANALYTICAL FRAMEWORK

In assessing the economics of HSGT in the United States, the study consistently applied a set of analytical components to a series of “cases”—specific technological options in illustrative corridors—as shown in Figure Chapter 3 -1.

Figure Chapter 3 -1: Flow of the Analysis



The process depicted above yielded two interlinked types of projection data. This chapter compares and contrasts these two data types, shows how they drew support from the various analytical components, demonstrates how they were synthesized in the concept of “partnership potential,” and introduces the illustrative cases that provided a basis for the report’s results and conclusions. Subsequent chapters describe the assumptions underpinning the work (Chapter 4) and the methodologies for each component (Chapters 5 and 6).

HSGT PROJECTION TYPES

This study characterizes HSGT corridor options in two ways:

- By their **system requirements and performance—**their initial investments, travel demand levels, revenues, operating expenses, and related operating and financial measures on a strictly commercial basis; and
- More comprehensively, by a **comparison of their benefits and costs.**

Both types of information are indispensable to a full understanding of HSGT and its potential role in American transportation.

In effect, projections of **system requirements and performance** treat HSGT options as analogous to private freight railroads—constructing and maintaining their own rights-of-way, providing their own equipment, and conducting their own transportation and ancillary operations. Such projections depict each HSGT corridor as a largely self-contained business enterprise.

Commercial projections alone may provide too narrow a perspective on the value of HSGT, because intercity passenger transportation in the United States is a joint product of public and private investments. Unlike America’s private freight railroads, each passenger travel mode—air, highway, and rail—shows distinctly split responsibilities for such essential functions as the provision, maintenance, and operation of rights-of-way, terminals, and vehicles. Thus, every means of intercity passenger transport in this country represents an implicit or explicit **private/public partnership** that—while incorporating user financing in large measure—also demonstrates governmental support and involvement.

Members of a private/public partnership will perceive a broader range of benefits and costs than those pertaining to strictly private enterprises. Therefore, an accurate portrayal of HSGT relies on a careful **comparison of benefits and costs** from a more comprehensive economic and environmental perspective than that provided by analogy with private freight railroads. While analysts may legitimately differ on the precise constituent elements and calculations of “benefits” and “costs,” this more global viewpoint merits consideration alongside strictly commercial projections for HSGT. With both types of projection data available, private firms, governments, and the general public can better appreciate the full implications of HSGT implementation.

ANALYTICAL COMPONENTS AND THEIR USES

As shown in Table Chapter 3 -1, the comparisons of benefits and costs relied on the full spectrum of analytical components, while the projections of system requirements and performance made use of a more limited set of procedures.

Table Chapter 3 -1: Analytical Components in Relation to Projection Types

Analytical component	Entered into projections of **System Requirements and Performance?**	Entered into comparisons of **Benefits and Costs?**
Capital Investments	**YES**	**YES**
Travel Demand and Revenues	**YES** [As an element of System Revenues]	**YES** [As an element of Benefits to HSGT Users; also measures Costs Borne by Users]
Operating and Maintenance Expenses	**YES**	**YES**
Ancillary Activities	**YES** [As an element of System Revenues]	**YES** [As an element of Benefits to HSGT Users; also measures Costs Borne by Users]
Users' Consumer Surplus	**NO**	**YES** [As an element of Benefits to HSGT Users]
Benefits To The Public At Large	**NO**	**YES**

The following sections describe the function of each of these tools in the two types of analyses.

System Requirements and Performance

Commercial projections encompassed four main analytical components: capital costs, travel demand and revenue forecasts, operating and maintenance expenses, and ancillary activities. For each case, these projected cash outflows and inflows were summarized in a discounted cash flow analysis.

Capital Costs

Cost estimates reflected the specific needs of each technology, appropriate Federal Railroad Administration safety guidelines and regulations (for example, regarding highway/railroad grade crossings), the characteristics of each corridor, and prevailing unit costs.

The initial investment would include upgraded or new track[1]; structures; communications and train control systems; electrification (where applicable to the technology); highway/railroad grade crossing safety enhancements; fencing and environmental mitigation measures; right-of-way acquisitions and realignments; stations, yards, and shops; locomotives, cars, and other vehicles; and an allowance for contingencies, engineering, and program management.[2]

In addition to the initial investment, this study addressed continuing investments by the HSGT operator—for instance, expansions and replacements of the vehicle fleet during the 40-year planning period.

Travel Demand and Revenue Forecasts

For each case, the analysis first projected travel demand by mode **in the absence of HSGT**. Fares for HSGT were then set to maximize net revenue given HSGT's competitive stance versus other modes in city-to-city markets. (The capital investments and consequent total travel times powerfully influence that competitive stance.) A series of **diversion models** projected the ridership that the new HSGT service would attract from air, auto, existing intercity rail, and bus. Depending upon the market, up to 10 percent of diverted traffic was added to reflect "induced demand," trips that would not take place at all by any mode without the introduction of HSGT. The ridership projections, multiplied by the fare levels and summed over all city pairs, yielded revenues for each corridor.

Operating and Maintenance Expenses

The projections for each case included a build-up of operating and maintenance (O&M) expenses in the functional areas of maintenance of way; maintenance of equipment; transportation; passenger traffic and services; and general and administrative. In each functional area, the O&M model identified all the required activities and calculated the resources—personnel, materials, energy, and purchased services—needed to perform those activities at the projected level of ridership and operations.

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[1] "Guideway" in the case of Maglev.
[2] Ranging from approximately 30% of base costs for Accelerail to 41% for New HSR and Maglev.

Ancillary Activities

In addition to intercity passenger service, the HSGT operator could conduct ancillary activities that conform with or support its main line of business. The analysis estimated, on an activity-by-activity basis, the net revenues from mail and priority express service, parking, station concessions, and certain on-board service amenities (e.g., telephones). Varying in importance from case to case, these net ancillary revenues cumulatively amount to between three and ten percent of system revenues.

Derivative Measures

The four analytical components yielded a variety of measures of system requirements, performance, and efficiency. For example, the HSGT operator's annual "operating surplus" is the difference between system revenues (i.e., passenger transportation revenue plus net revenue from ancillary activities) and O&M expenses. The "surplus after continuing investments" is the present value of the future operating surpluses, less the present value of continuing investments projected to be made by the HSGT operator in future years. Chapter 7 describes these derivative measures in detail.

Comparisons of Benefits and Costs

To provide policy makers and the public with comprehensive information that would support a wide variety of interpretive techniques, this analysis attempted to quantify the full range of benefits and costs attributable to HSGT systems, as well as the parties on whom such benefits and costs might fall.

Total Benefits

As measured in this report, total benefits comprise the following elements:

- **Benefits to HSGT users** reflect the economic theory that travelers will pay only for transportation whose worth to them is equal to or greater than the applicable fare. Thus, the benefits to HSGT users consist of two elements:
    - — **Benefits for which users must pay:** the product of the number of riders and the fares.[3] This equates to **system revenues** and was estimated as part of the projections of system requirements and performance.
    - — The **users' consumer surplus,** which represents the difference between the full value of HSGT transportation to passengers and

[3] Income from ancillary activities is also included on the same economic grounds.

the fares they would pay. The surplus arises because fare levels are set to maximize net revenues rather than to exact payment from each traveler for the full worth of the transportation provided.[4]

- **Benefits to the public at large** redound to the general public and to users of modes other than HSGT. These benefits recognize the effects of diverting significant passenger volumes from existing modes to HSGT, and consist of savings from alleviated congestion and reduced emissions in air and highway travel.

These elements can be included in total HSGT corridor benefits because they are quantifiable in dollar terms and involve neither double counting nor transfers from one region or type of project to another.[5] On the other hand, total benefits do not include certain items that—although quantifiable—either duplicate the included benefits or represent "transfer effects" that might just as well accrue in other locations due to other major investments. Examples include economic impacts from HSGT operations and construction; capital savings on airports and highways; and energy savings. From the nationwide viewpoint of this report, such duplicative or transfer impacts—while of interest to potential partners in the development of specific corridors—could not appropriately enter into the projected total benefits of each HSGT corridor.

In addition, some impacts did not readily lend themselves to systematic quantification (for example: benefits to the American HSGT equipment industry; impacts on the automobile or aircraft industries) or required site-specific data exceeding the scope of this national study (for instance, such environmental impacts as noise and water pollution). Such items may merit scrutiny in studies of specific corridor proposals at the State level.

Total Costs

Total costs consist of the following:

- The **initial investment in HSGT infrastructure and vehicles;**
- **O&M expenses;** and
- **Continuing investments** necessary (after initial system construction) to assure capacity for future traffic growth.

[4] The models used to project revenues in studies of this type do not incorporate the oft-changing fares—keyed to such factors as the precise date and time of travel, overnight stay requirements, amount of advance booking time, and competing carriers' prices—that characterize yield management in modern passenger transport companies. To the extent that an actual HSGT operator exceeds this report's projections by implementing sophisticated yield management techniques that maximize net system revenues while forcing each rider to pay a fare that approaches the full value of the transportation to him or her, then "users' consumer surplus" will be converted to "system revenues."

[5] See Chapter 6 for the criteria for inclusion in total benefits.

Viewed from the perspective of incidence, total costs fall into two fundamental categories:

- **Costs borne by users** (this equates to system revenues); and
- **Publicly-borne costs** (total costs less system revenues).

PARTNERSHIP POTENTIAL DEFINED

Recognizing the current structure of the intercity passenger transport industry, this report assesses HSGT cases for their **partnership potential—**their apparent capacity to draw the private and public sectors together in planning, negotiations, and, conceivably, project implementation. Partnership potential broadly gauges the attractiveness **to State and local governments** of an HSGT project but does not address the project's advisability, equity, or worth from the public policy perspective, nor its practicability from the financial viewpoint. Only detailed studies at the State level can fully treat the latter topics.

To exhibit partnership potential as defined in this report, the projections for an HSGT technology in a particular corridor must satisfy at least the following two conditions (see Figure Chapter 3 -2), which respectively address system requirements and performance, and comparisons of benefits and costs:

First, **private enterprise must be able to run the corridor—once built and paid for—as a completely self-sustaining entity.** Thus, over the planning period, the HSGT operator's total revenues would need to cover not only the corridor's operating and maintenance expenses but also its continuing investment needs, such as for new vehicles to replace and expand the fleet. This condition would assist in attracting a private operator and would provide reasonable assurance to the public that its initial investment in HSGT is, indeed, a one-time contribution, not a prelude to continuing operating or capital subsidies. By positing a system free of operating subsidies, this report clearly differentiates between future HSGT corridor development and existing intercity passenger rail transportation.

Second, the total benefits of an HSGT corridor must equal or exceed its total costs. [6,7] As described below, other approaches to measuring benefits and costs may be of equal or greater interest to policy makers as they consider specific HSGT projects.

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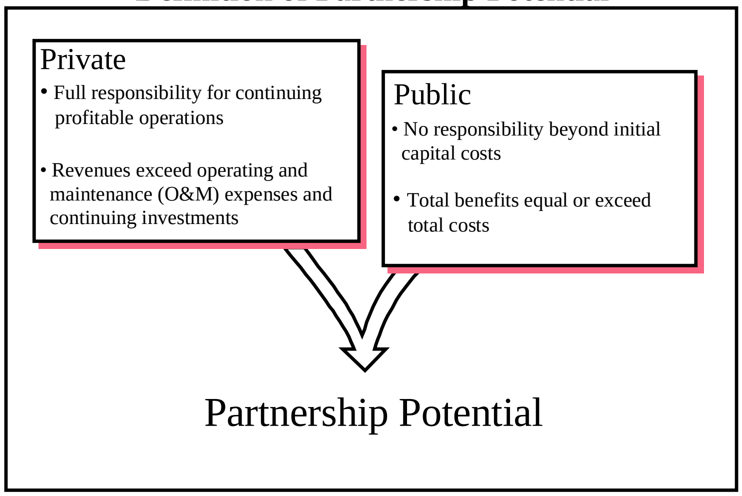
[6] Total benefits and total costs are expressed as present values, as of the year 2000, over the planning period (2000—2040).

[7] Chapter 5 describes in detail the methodology for projecting system requirements and performance, while Chapter 6 does the same for the comparisons of benefits and costs.

Figure Chapter 3 -2
Definition of Partnership Potential



This report uses "partnership potential" as an indicator of the aggregate financial and economic impacts of HSGT alternatives in a set of illustrative corridors. Detailed State studies of individual corridors would benefit from site-specific investigations and data as well as additional evaluation measures. Thus, <u>while "partnership potential" may offer useful insights in assessing the likelihood of HSGT development by State and local governments and their private partners, it does not constitute an express or implied criterion for Federal approval or funding.</u> Any future Federal consideration of specific HSGT project proposals could apply additional criteria (e.g., comparisons of benefits to the public at large with publicly-borne costs) that could differ from, and be much more stringent than, this report's threshold indicators for "partnership potential."

Owing to locally perceived transportation conditions and business opportunities, States and private entities may still see partnership potential in options that lack it according to this report. Clearly, as long as States can develop the requisite financing, they can choose their own measurement techniques and thresholds to reflect local and regional public priorities.

ADDITIONAL MEASURES OF PARTNERSHIP POTENTIAL

State studies will inevitably use additional measures to assess whether early indications of partnership potential[8] can withstand further, necessary scrutiny. Examples of these additional measures include, but are not limited to, the following.

[8] Such as the findings of this report and of other preliminary investigations at the State level.

Financial Measures

It is highly desirable that the private sector should be able to make a substantial contribution, based on operating surpluses, toward the initial capital investment. Indeed, the potential for private/public partnerships becomes larger the higher the percentage of initial investment that can be covered by operating surpluses.

Furthermore, the absolute size of the initial investment requirement will strongly influence partnership potential, since different States and private consortia will have different capacities for assembling the financing required for a proposed HSGT project.

Benefit/Cost Measures

In performing definitive feasibility studies of HSGT systems, policy makers and the public may deem it essential to compare not just total benefits with total costs, but also the benefits and costs accruing to users and the public at large respectively. Comparisons of benefits to the public at large with publicly-borne costs, for instance, would allow policy makers to determine the degree to which the public at large would obtain a return on its investment in HSGT.

CASES

To assess the economics and the partnership potential of HSGT, the study applied its analytical components to **cases**, each of which paired a particular technology with a single illustrative corridor.

Technologies

The family of available HSGT options includes three groups: accelerated rail service (“Accelerail”), new high-speed rail systems (“New HSR”), and magnetic levitation (“Maglev”), in order of increasing performance capabilities and initial cost. This section pinpoints the salient characteristics of each of the HSGT technologies. Further specifications appear in Chapter 4.

Accelerail constitutes upgraded intercity rail passenger service on existing railroad rights-of-way, most of which belong to the freight railroads. The Accelerail options considered in this report have top speeds ranging from 90 to 150 mph.[9] At the lower

[9] The Accelerail 150 options generally assume a greater separation of passenger from freight service—see Chapter 4.

Table Chapter 3 -2
The Accelerail Options

Top Speed (mph)	Non-electrified options	Electrified options
90	90	not analyzed
110	110	not analyzed
125	125F[10]	125E
150	150F[10]	150E

speed levels, only non-electrified systems[11] underwent scrutiny; the higher speed regimes comprised both electrified[12] and non-electrified motive power. (See Table Chapter 3 -2.) Typical Accelerail-type systems include today's Metroliners between New York City and Washington, as well as the X-2000 in Sweden and the InterCity 225 service in the United Kingdom.

Two fundamental means exist to accomplish Accelerail[13]; these usually occur in combination, based on projections of time savings, net revenue impacts, and life-cycle costs:

- Improve the infrastructure (including, for example, track and structures) to allow for higher top speeds, remove site-specific speed restrictions (e.g., in urban areas, around curves, through switches), and offer higher line throughput capacity and enhanced reliability; and/or
- Improve the fleet of locomotives and cars (sometimes permanently or semi-permanently attached in larger units called "trainsets") to provide better acceleration, to achieve higher maximum speeds, and to alleviate the need to slow down for curves by providing additional banking within the vehicle ("tilt").

In addition to promising favorable operating results, efforts to upgrade existing service to Accelerail levels must adhere to evolving safety standards, the stringency of which generally increases with speed.

Costs to implement Accelerail solutions vary with two basic factors:

- The existing ownership, condition, freight and commuter traffic, and capacity of the rail line to be improved; and
- The future institutional arrangements, standards of service, and projected levels of traffic of all types.

Making use of existing facilities, Accelerail ordinarily represents the least ambitious and least expensive HSGT technology and may provide relatively high benefits in

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[10] Assumes successful development of non-electric locomotives capable of these speeds, with performance substantially equivalent to existing electric high-speed locomotives.
[11] That is, powered by on-train heat engines.
[12] Powered by remote power plants with electrical power distributed to trains via a system of overhead wires.
[13] The distinction is not hard and fast: certain system elements, such as train control and electrification, rely on a perfectly coordinated set of vehicle, right-of-way, and other improvements. In addition, even in the absence of line-haul trip-time savings, some reductions in total (door-to-door) travel times could conceivably occur—for example, through station relocations, additions, and reconfigurations; through parking and other access betterments; through higher train frequencies; and through streamlined ticketing and other processes.

comparison with the investment required. Nevertheless, Accelerail solutions require concerted attention to the needs and operations of the freight railroads, which own most of the rights-of-way and which already provide a transportation service that is of supreme importance to the Nation's commerce. Accelerail's success thus depends on its ability to secure the cooperation of the railroad companies.

New HSR represents advanced steel-wheel-on-rail passenger systems on almost completely new rights-of-way. Through a combination of electrification and other advanced components, expeditious alignments, and state-of-the-art rolling stock, New HSR can attain maximum practical operating speeds on the order of 200 mph.[14] On the other hand, because it is compatible with existing railroads, New HSR can combine new lines in rural areas with existing approaches to urban terminals, and can offer Accelerail-type services beyond the confines of the New HSR lines *per se.*

The bulk of New HSR research and development has taken place after World War II in Japan, France, and Germany. Japan introduced the world's first New HSR—the *Shinkansen* (or "bullet train")—in 1964; France followed with its *train à grande vitesse* (TGV), and Germany with its Intercity Express (ICE). Other countries have followed suit. Although adhering to sometimes divergent design principles,[15] New HSR systems have uniformly succeeded in reducing journey times and capturing increased traffic among the major cities served.

New HSR has the benefit of a technology that has seen many successful years of revenue operation, that can compete on a door-to-door basis with air trip times, that has a cost structure confirmed by experience, and that allows for smooth linkages with other rail services. Unlike Accelerail, however, New HSR makes relatively sparing use of existing facilities and thus must support the higher costs—as well as the environmental reviews and mitigation requirements—associated with all new infrastructure projects.

Maglev is an advanced transport technology in which magnetic forces lift, propel, and guide a vehicle over a special-purpose guideway. Utilizing state-of-the art electric power and control systems, this configuration eliminates the need for wheels and many other mechanical parts, thereby minimizing resistance and permitting excellent acceleration, with cruising speeds on the order of 300 mph.[16] This high performance would enable Maglev to provide air-competitive trip times at longer trip distances than the other HSGT options.

There are two basic types of Maglev. One type is based on attraction forces: electromagnets exert force on an iron rail on the guideway to effect levitation. The second

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[14] The French National Railways (SNCF), for example, has successfully tested steel-wheel-on-rail systems at speeds well in excess of 200 mph.
[15] The French system was designed for passenger trains only, whereas the German New HSR lines initially allowed for freight traffic as well.
[16] Even higher speeds are possible.

type is based on repulsion forces: superconducting magnets move across coils or aluminum plates on the guideway to propel and levitate the vehicle. Typically, the attraction-force Maglev has a gap of about one-half inch and can be levitated at zero speed. The repulsion force Maglev has a gap of about four inches and must be in motion for levitation to occur.

Germany has an attraction-force Maglev technology, Transrapid, ready for commercial use and planned for implementation in the Berlin-Hamburg corridor. Japan has a repulsion-force Maglev system under testing. The National Maglev Initiative (described in Chapter 1) developed performance guidelines for a U.S. Maglev system, which would improve on foreign systems in several respects[17]; those guidelines are incorporated in the Maglev case studies in this report. However, prototype development for a domestic Maglev design has not occurred.

In view of Maglev's advanced performance capabilities, the guideway and related propulsion, levitation, and guidance technology are more expensive than for New HSR: Maglev initial infrastructure costs amount to about 20 to 50 million dollars per route-mile, compared to about 10 to 45 million dollars per mile for some of the most advanced steel-wheel-on-rail systems, and $1 to $10 million for the various Accelerail options.

Maglev can provide air-competitive trip times and top-quality service in the 100-500 mile range considered in this report, and thus can generate very high ridership, revenues, and public benefits. Against that incomparable performance potential must be weighed Maglev's relatively high initial cost, its need for environmental reviews and mitigating measures appropriate for new construction, its lack of revenue service thus far, and its inability to offer same-train services extending beyond the limits of the Maglev line.[18]

In summary, the HSGT technologies represent a diverse portfolio of inherent capabilities and drawbacks. As demonstrated in Table Chapter 3 -3, none of these technologies constitutes an intrinsically "perfect" solution; were they cost-free, they would already exist nationwide. Moreover, the relative benefits and costs of the HSGT options vary significantly with the contexts in which they are modeled—with the topography, demographics, economic characteristics, and transportation infrastructure and markets of the individual corridors. It is to those corridors that this report now turns.

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[17] *Final Report on the National Maglev Initiative*, DOT/FRA/NMI-93/03, September 1993.

[18] The last two factors mentioned—lack of revenue service and incompatibility with existing technology—characterized all new technological initiatives, from the railroads of the early 1800s to the automobile and airplane at the turn of the century, to the compact disc of today.

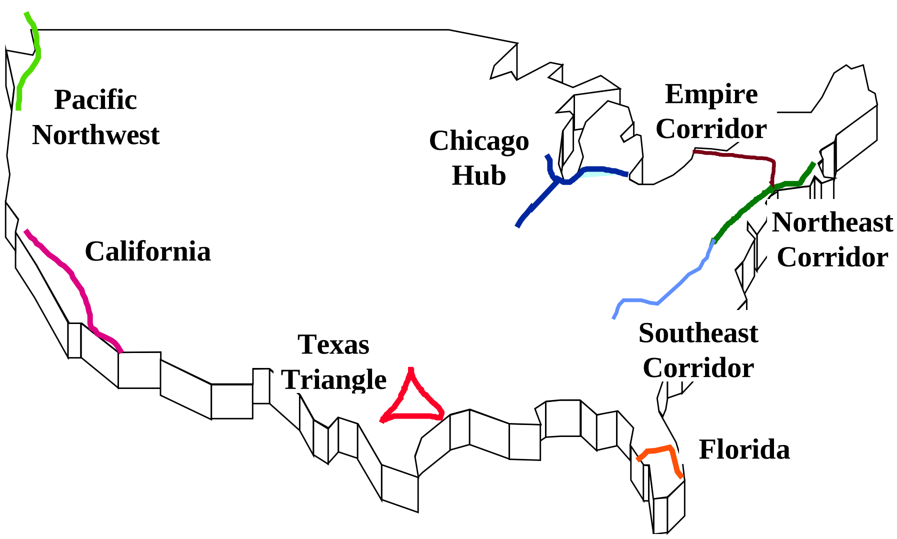
Table Chapter 3 -3
Selected Inherent Advantages of HSGT Technological Options[19]

Selected Characteristics	Advantages of Technologies With Respect To Each Other (+ means the technology has an apparent inherent advantage)		
	Accelerail	New HSR	Maglev
Trip-time and revenue performance		+	+
Initial cost	+		
Autonomy from existing railroads		+[20]	+
Through train potential over other railroads	+	+	
Service-proven technology and cost structure	+	+	

Corridors

The analytical components were consistently applied to a set of illustrative corridors depicted in Figure Chapter 3 -3.

Figure Chapter 3 -3
The Illustrative Corridors



Providing a broad spectrum of configurations, lengths, and travel densities, these corridors represent:

- **Existing corridors in which passenger trains regularly operate at speeds of 110 mph and above—**

[19] These advantages are generic and do not address the relative performance of the options in specific corridors. For example, the "selected characteristics" may be weighted differently in one corridor than in another, and other characteristics may be of prime importance in certain corridors.
[20] New HSR would be autonomous over its dedicated rights-of-way, but would make limited use of existing railroads in some urban areas.

— Northeast Corridor (Boston—New York City—Washington);

— Empire Corridor (New York City—Albany—Buffalo).[21]

- **The five potential HSGT corridors designated by the Secretary of Transportation for special grade crossing safety funds under Section 1010 of the ISTEA.** To be so designated, the ISTEA required that the corridor contain rail lines where railroad speeds of 90 mph are occurring or can reasonably be expected to occur in the future, and that other operational, financial, and institutional criteria be met.[22] The Section 1010 corridors are:

  — Pacific Northwest Corridor;

  — California Corridor;

  — Chicago Hub;

  — Florida Corridor; and

  — Southeast Corridor[21]; and

- The **Texas Triangle**, which presents a unique nonlinear configuration of heavily populated metropolitan areas.

The study also derived, by truncation, additional illustrative corridors from the basic eight. Specifically, the Chicago Hub underwent scrutiny as a unified network (with three spokes—between Chicago and Detroit, St. Louis, and Milwaukee), while the Chicago—Detroit and Chicago—St. Louis corridors also received separate attention. Similarly, the study addressed both the California Corridor as a whole (San Francisco Bay Area—Los Angeles—San Diego) and the segment between Los Angeles and San Diego.

Two of the illustrative corridors—the Empire and the Southeast—connect directly with the existing high-speed Northeast Corridor, at New York City and Washington, D.C., respectively. Marketing considerations would dictate an operating plan that builds upon these connections, by means of either through service (where possible technologically) or carefully coordinated schedules. Therefore, this study treated the Empire Corridor and the

[21] For corridors connecting with (and treated as extensions of) the Northeast Corridor, this study included the effects of the through traffic. For example, the Empire Corridor's traffic levels included passengers between Philadelphia and Albany, Wilmington and Albany, and similar city pairs. See chapter 8.

[22] Specifically: "Projected rail ridership volumes in such corridor, the percentage of the corridor over which a train will be capable of operating at its maximum cruise speed, projected benefits to nonriders such as congestion relief on other modes of transportation, the amount of State and local financial support that can reasonably be anticipated for the improvement of the line and related facilities, and the cooperation of the owner of the right-of-way that can reasonably be expected in the operation of high speed rail passenger service . . ."

Southeast Corridor incrementally—as an addition to Northeast Corridor high-speed service—rather than independently. Chapter 8 provides specifics on this treatment.

Although intended to be strictly illustrative, the study corridors still encompass almost three-fifths of the Nation's total metropolitan area population, 75 percent of the people living in the 50 most heavily populated metropolitan areas, and 90 percent of the inhabitants of the 17 metropolitan statistical areas with populations of 2.5 million or more.[23]

Matrix of Cases

A case is a specific **technology** projected in a specific **corridor.** The cells of the matrix in Table Chapter 3 -4 represent the universe of cases that **could have been** modeled; the shaded cells are those that **were** modeled for this study. The rules for selecting cases for projections were as follows:

- Cases representing levels of service that already exist in full, or will be in place by the Year 2000, were omitted.[24]
- From an engineering perspective, the freight railroad right-of-way in certain corridors[25]—by virtue of its curvature, existing freight traffic levels, or other constraints—cannot provide a practical basis for the Accelerail 150 option, which thus was not modeled.
- The Texas Corridor presents an analytical challenge since it can undergo scrutiny in at least seven ways.[26] This study completed projections for the **entire** triangle under **all** technologies.
- All other corridors received full scrutiny under all technological options.

[23] Derived from U.S. Bureau of the Census, *Statistical Abstract of the United States—1995,* table 43; 1990 census data.

[24] E.g., all Accelerail options up to and including 150 in the Northeast Corridor.

[25] I.e., the Northwest Corridor, San Diego—Los Angeles, Florida, and the Southeast Corridor.

[26] The three sides of the triangle together; the three sides individually; and three combinations of two sides each. Also, there are multiple routing possibilities for the Accelerail options.

Table Chapter 3 -4
Cases Analyzed and Reported

LEGEND: Borders and shading indicate that the case—combining the technology shown in the column with the illustrative corridor named in the row— was modeled for this study and reported on herein.

Corridors	**Accelerail**						**New HSR**	**Maglev**
	90	**110**	**125F**	**125E**	**150F**	**150E**		
California North/South (San Diego—Los Angeles—San Francisco Bay Area)								
California South (San Diego—Los Angeles)								
Chicago Hub Network (Chicago to Detroit, St. Louis, and Milwaukee)								
Chicago—Detroit								
Chicago—St. Louis								
Florida (Tampa—Orlando—Miami)								
Northeast Corridor (NEC) (Boston—New York—Washington)								
Pacific Northwest (Eugene-Portland-Seattle-Vancouver, B.C.)								
Texas Triangle (Fort Worth-Dallas-Houston-San Antonio)								
Empire Corridor: New York-Buffalo (treated as an extension of the NEC)[27]								
Southeast Corridor: Washington-Richmond-Charlotte (treated as an extension of the NEC)[27]								

[27] For the Empire and Southeast Corridors, analysis was completed on Maglev, New HSR, and one sample Accelerail case. See Chapter 8. Future, more detailed studies may yield more promising results for other Accelerail options than those completed for this report.

Chapter 4
GENERAL ASSUMPTIONS

The key assumptions affecting the results of this study fall into three categories: financial, economic, and transportation-related. This chapter presents all three groups of general assumptions.

FINANCIAL ASSUMPTIONS

In assessing the potential of HSGT, the study made a series of financial assumptions consistent with Federal practices. While internal financial thresholds may differ for each of the partners in any HSGT project, the following assumptions provide a consistent means of comparing the various cases, technologies, and illustrative corridors:

- **Planning period—**This is the period from the year 2000[1] to 2040 in which operations and continuing investments occur.
- **Monetary values—**Unless otherwise labeled, monetary values are 1993 constant dollars and are present values as of the beginning of the assumed first year of operation in 2000.
- **Discount rate—**The study applied a ten percent discount rate (real) to the revenues, operating expenses, and continuing investments projected for the HSGT entity, which is presumed to be a private firm.[2] Initial investments, assumed to pertain to the public sector, incorporate the Office of Management and Budget's discount rate of seven percent (real), as do the monetized values of all benefits except for those measured by system revenues.
- **Salvage value—**No salvage value (residual value of the investment at the end of 2040) was added to the cases' present value.
- **Construction period—**This period consists of the three years prior to 2000 (two years for vehicles). Initial construction activities were assumed to be evenly spread over the construction period, and the reported investments are the present values as of the year 2000 of the costs incurred in prior years (i.e., they are inflated at a rate of seven percent from the year of incurrence).

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[1] The year 2000 was used for analytical purposes only, in order to keep the cases comparable; achievable startup dates would vary widely by technology and corridor.
[2] See also under "The HSGT Operating Entity," page 4-12.

- **Cash basis—**The projections deal with cash inflows and outflows and treat plant and equipment replacements as continuing investments in the year incurred. This treatment recognizes phenomena of the type that would have been addressed in an annual allowance for depreciation had such an allowance been included in operating expenses.
- **Taxes—**The study assumed that the HSGT entity, as a member of a private/public partnership, would not be liable for property taxes on HSGT facilities and equipment, and would have no requirement for cash payment of income taxes related to its HSGT operations during the study period.

NATIONAL TRENDS

Population and income growth serve as the two key exogenous demographic parameters shaping the demand for transportation. This study used forecasts from the Bureau of Economic Analysis (BEA) of the U.S. Department of Commerce on a metropolitan-area-specific rather than a national-average basis to best reflect the demographics of each corridor. Underlying these metropolitan-area forecasts, however, are the BEA forecasts for nationwide annual compounded growth rates, as shown in Table Chapter 4 -1.

Table Chapter 4 -1
Underlying Population and Income Growth Rates from BEA

Time period	Population growth rate[3]	Income growth rate[4]
1993-2000	0.99%	2.27%
2000-2010	0.84%	1.92%
2010-2020	0.82%	1.60%
2020-2030	0.71%	1.54%
2030-2040	0.60%	1.47%

[3] Population growth rate derived from: Bureau of Economic Analysis, *BEA Regional Projections to 2045*, Diskette #61-95-40-201, July 1995; Bureau of the Census, *Population Projections of the United States, by Age, Sex, Race, and Hispanic Origin: 1993-2050*, November 1993, p. xii.
[4] Income growth rate derived using total personal income data from Bureau of Economic Analysis, op. cit.

THE TRANSPORTATION ENVIRONMENT

This section reviews the scope of intercity passenger transportation covered in the study and characterizes the established non-HSGT modes as they are envisioned during the planning period.

Scope of Transportation

In analyzing transportation by all modes in the illustrative corridors, this study examined city-pair markets in which HSGT could compete with air and/or auto on door-to-door travel time. Hence, the study concentrated primarily on city-pairs approximately 100 to 500 miles in length. The data base for the study therefore omitted trips under 50 miles as well as trips restricted to a single metropolitan statistical area (MSA) or consolidated metropolitan statistical area (CMSA); such trips would have more in common with mass transit than with intercity travel, or would be so heavily weighted toward access rather than line-haul time as to dilute the time savings effected by HSGT. In short, this is an intercity, not a transit study.

Trends in Other Modes

The projected shape of the transportation world in the absence of HSGT (a condition termed "baseline") profoundly affected the study results. This section accordingly summarizes the assumed and derived trends in the intercity passenger transport world.

Fuel Availability and Price

Petroleum-based fuels were assumed to be in constant supply over the projection period: no repetition of the gasoline shortages of 1973 and 1979 was foreseen. Moreover, real fuel prices were assumed to remain constant through 2040, although the Department of Energy recently predicted increases in energy fuel prices[5] due to shrinking resources, capital investments in more efficient technology, and more stringent environmental regulations. Any assumed increases in energy prices would have favorably affected the projections for HSGT, both by raising the fare levels of competing, energy-intensive modes and by giving most HSGT options a relative advantage in unit operating expenses for energy. Instead of showing improved HSGT results on the basis of a world commodity

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[5] Energy Information Administration, *Annual Energy Outlook 1994: With Projections to 2010*, DOE/EIA-0383(94), pp. 2 and 30-39. The crude oil prices are expected to have an average annual growth rate of 1 percent; natural gas prices are expected to rise at an annual rate of 3.3 percent; and coal prices increase at a moderate annual rate of 1 percent. The electricity price is forecast to increase at an average annual rate of 0.3 percent.

market that has been unpredictable in the past,[6] this study found it more judicious to assume an unchanging energy environment.

Fares and Perceived Costs

Fares for all existing modes (perceived costs in the case of auto) were assumed to remain constant, in real terms, over the planning period. Thus, the projections in this report do not incorporate the effects of “fare wars”—characterized by marked fluctuations in tariffs and predatory pricing—that might occur among modes upon the introduction of HSGT service in a given corridor.[7]

Fares for public modes reflected a statistical analysis of actual 1993 traffic records, which yielded typical fares for business and non-business trip purposes. For auto, the study assigned a higher perceived cost to business travel ($0.16 per passenger-mile) than to non-business travel ($0.08 per passenger-mile). The former reflected the full cost of auto ownership (including depreciation and insurance), while the latter treated intercity travel as an incremental “out-of-pocket” expense and omitted ownership costs.

Frequencies

Frequencies for existing modes were assumed to grow at the following rates per decade:

Mode:	**Air**	**Auto**	**Conventional rail**	**Bus**
10-year rate of growth:	Based on traffic growth less any diversions to HSGT	Not applicable (infinite frequency)	10%	10%

Travel Times

With the exception of the congestion and capacity effects described below, trip times in the existing modes were assumed to remain constant over the planning period.

Growth in Demand

Table Chapter 4 -2 shows the projected annual growth rates, by period, in baseline travel demand for the existing modes. These are averages, across all the illustrative corridors, of growth rates developed for this study. Comparing the baseline growth rates with available FAA and FHWA forecasts, Table Chapter 4 -3 and Table Chapter 4 -4 demonstrate that this analysis incorporates much less growth in other modes than is

[6] Forecasters failed to predict the oil crisis of the 1970s, for example.
[7] Chapter 8 contains a sensitivity analysis and other information on the extent of low-fare air service.

foreseen nationwide by the relevant agencies. For example, assumed air traffic growth to the year 2000 is about one third less than FAA's projection, and assumed auto growth is about one quarter less than FHWA's.

Table Chapter 4 -2
Average Baseline Growth Projections for Existing Modes in CFS Corridors

Period	Projected Annual Growth Rates by Mode in Each "Decennial" Period				
	Air O/D	Air Transfer	Auto	Rail	Bus
1993-2000	2.36%	2.06%	1.85%	2.03%	1.79%
2000-2010	2.23%	2.23%	1.85%	1.96%	1.90%
2010-2020	1.83%	1.86%	1.56%	1.67%	1.58%
2020-2030	1.87%	1.90%	1.58%	1.72%	1.59%
2030-2040	1.87%	1.90%	1.58%	1.72%	1.59%

Table Chapter 4 -3
Comparison of Available FAA Forecasts
With Air Baseline
(Average Annual Growth Rates During Period)

Period	Air Baseline for This Study[8]	FAA Nationwide[9]
1993-2000	2.36%	3.5%
2000-2010	2.23%	2.9%
2010-2020	1.83%	2.3%
2020-2030	1.87%	—
2030-2040	1.87%	—

Table Chapter 4 -4
Comparison of Available FHWA Forecasts
With Auto Baseline
(Average Annual Growth Rates During Period)

Period	Auto Baseline for This Study[10]	FHWA Nationwide[11]
1993-2000	1.85%	2.5%
2000-2010	1.85%	—
2010-2020	1.56%	—
2020-2030	1.58%	—
2030-2040	1.58%	—

[8] This is the average growth in air origin/destination traffic within the illustrative corridors for this study.
[9] Derived from Federal Aviation Administration, *FAA Aviation Forecasts, Fiscal Years 1994-2005*, FAA-APO-94-1, March 1994, p. I-9; Office of Aviation Policy, Plans and Management Analysis, *FAA Long-Range Aviation Forecasts: Fiscal Years 2005-2020*, FAA-APO-94-7, July 1994, p. 9.
[10] This is the average growth in auto intercity traffic within the illustrative corridors for this study.
[11] Forecast using total vehicle miles traveled. Data from: Report of the Secretary of Transportation to the U.S. Congress, *The Status of the Nation's Highways, Bridges, and Transit: Conditions and Performance*, 1993, p. 158.

Congestion and Capacity Effects

As demonstrated in Chapter 2, the air and auto modes in recent decades have exhibited inexorably growing demand, with which capacity has not kept pace. In projecting conditions for air and auto, this study has assumed that, although some of the capacity additions identified by the Department for other modes[12] will come about, discrepancies between travel volumes and infrastructure growth will continue to widen, with some congestion-driven increases in automobile trip times, urban access times to stations of all public modes (including HSGT itself), and air schedules. Delay estimates were developed for each Metropolitan Statistical Area or Consolidated Metropolitan Statistical Area on the basis of site-specific highway congestion[13] and airport studies. In addition to affecting somewhat the characteristics of the various modes for demand estimation purposes,[14] the projected increases in auto and air congestion provided a starting point for estimating public benefits of HSGT (see Chapter 6).

HSGT System Concept Assumptions

This section describes the technological, operational, fare-setting, and institutional assumptions for the HSGT systems modeled in the study.

Technologies

Vehicles and Performance

Table Chapter 4 -5 presents the assumed specifications for the eight technological options already enumerated in Chapter 3.

Three main categories of motive power were assumed: non-electrified,[15] electrified,[16] and linear electric (Maglev) propulsion. The study assumed that non-electrified Accelerail technologies through 125F would use Diesel locomotives.[17]

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[12] Federal Aviation Administration, *1994 Aviation Capacity Enhancement Plan*, DOT/FAA/ASC-94-1, October 1994, pp. 7-1 to 7-4; Report of the Secretary of Transportation to the U.S. Congress, *The Status of the Nation's Highways, Bridges, and Transit: Conditions and Performance*, Chapters 3 and 4.

[13] Texas Transportation Institute (TTI), *Trends in Urban Roadway Congestion—1982 to 1991, Volume 1: Annual Report*, Research Report 1131-6, College Station: TTI, September 1994.

[14] While altering total trip times, the recognition of congestion effects over the planning period did not significantly change the relative competitive positions of the modes in key city pairs.

[15] That is, the prime energy source is on the train (rather than at an off-train electric generating station). Since the prime mover is an on-board **fossil**-fueled heat engine, these non-electrified options are designated as "F" in speed regimes for which electrified ("E") options are also studied.

[16] That is, powered by a remote generating station.

[17] In reality, Diesel locomotives ordinarily transfer their power to the axles by means of electricity (hence the more accurate term "Diesel-electric"), and gas turbine engines can use a similar means of power transfer.

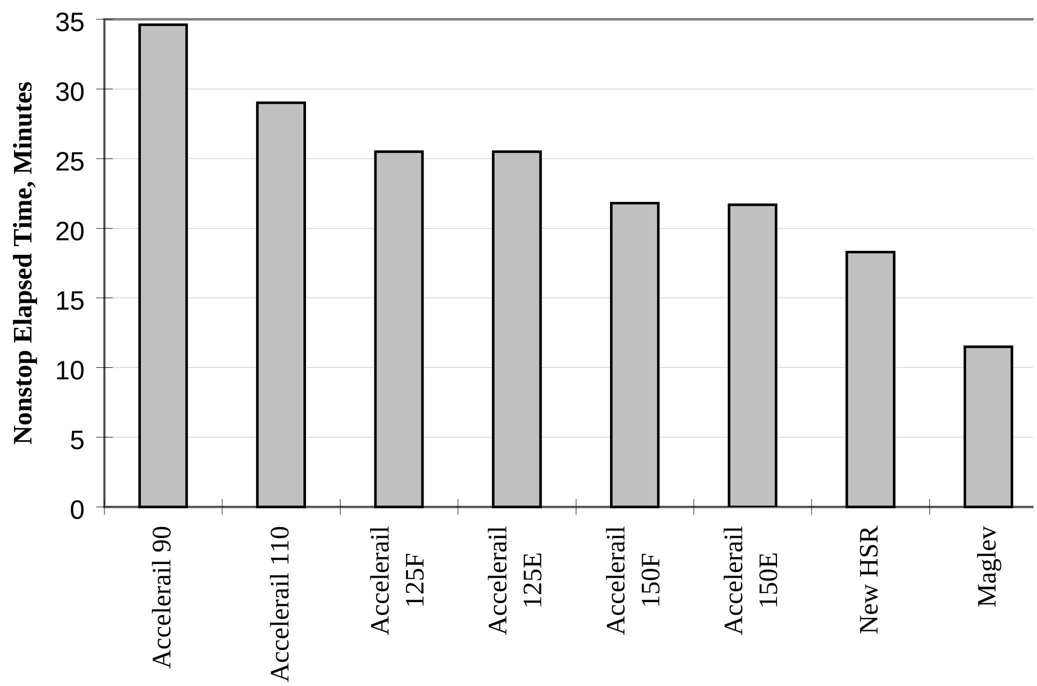
Table Chapter 4 -5
Summary of Technologies

Technology (Top Speed, Propulsion, Horsepower (hp))	Con-sist[18]	Weight	Seats	Weight/seat	Hp/ton	Accel-eration[19]	Comments[20]
Accelerail							
90 (Non-Electrified) 3500 hp	1-4	346 ton 1-4 trainset (130 ton locomotive)	264	1.31 ton/seat	10.1	0-90 2.7 min.	Based on P-40 (AMD103) with X-2000 type Coaches
110 (Non-Electrified) 4000 hp (min.)	1-4	346 ton 1-4 trainset (130 ton locomotive)	264	1.31 ton/seat	11.6	0-110 4.0 min.	Based on modified Diesel with X-2000 type Coaches
125F (Non-Electrified) 5200 hp (min.)	1-4	326 ton 1-4 trainset (110 ton locomotive)	264	1.23 ton/seat	16.0	0-125 3.88 min.	Based on advanced Diesel (110t) with X-2000 type coach
125E (Electrified) 7000 hp/locomotive	1-4	316 ton 1-4 trainset (100 ton locomotive)	264	1.2 ton/seat	22.2	0-125 2.7 min.	Based on AEM-7 with X-2000 type Coaches
150F (Non-Electrified) 7000 hp/locomotive	1-4	316 ton 1-4 trainset (100 ton locomotive)	264	1.2 ton/seat	22.2	0-150 4.1 min.	Based on Advanced Turbo/Diesel Flywheel combination
150E (Electrified) 7200 hp/locomotive	1-4	306 ton 1-4 trainset (90 ton locomotive)	264	1.16 ton/seat	23.5	0-150 2.9 min.	Based on improved AEM-7 with X-2000 type Coaches
New HSR							
200 (Electrified) [21] 6000 hp/power car	1-8-1 (1-6-1)	460 ton 1-8-1 (1-6-1 390t) (73 ton power car)	388 284	1.19 ton/seat 1.37 ton/seat	26.1 30.8	0-200 5.7 min.	Based on TGV-A 1-8-1
Maglev							
300 (Maglev—Linear electric) [22] 12000 hp/car	2 car 4 car	45 ton nose (65/85 seats) 45 ton middle (105 seats)	150 325	0.6 ton/seat (2) 0.5 ton/seat (4)	150 150	0-300 1.5 min.	Based on U.S. Maglev with ride comfort limit 0.16g acceleration

[18] "1-4" means one locomotive (or power car) and 4 coaches.
[19] In number of minutes from zero to top speed in miles per hour.
[20] References to existing equipment are solely for the purpose of conveying to readers the generic type of vehicles envisioned and do not imply endorsement of specific products or manufacturers. It is assumed that all equipment actually operated over HSGT corridors will fully comply with all then-applicable Federal safety regulations.
[21] The choice between the 1-8-1 and the 1-6-1 consist was made on a corridor-specific basis reflecting demand, load factors, and frequencies.
[22] The choice between the 2-and 4-car consist was made on a corridor-specific basis reflecting demand, load factors, and frequencies.

Accelerail 150F was posited as a performance goal for technology development in the Federal Railroad Administration's Next-Generation High-Speed Rail Program, and as such could make use of a variety of motive power innovations now under investigation. New HSR and electrified Accelerail options would require the construction of catenaries (overhead wires) and support systems to distribute power to the HSGT trains. Maglev would operate via linear electric motors providing noncontacting propulsion and would require its own guideway system.

Figure Chapter 4 -1
Nonstop Elapsed Time by Technology Over a 50-Mile Straight Course



Thus, the six Accelerail options, New HSR, and Maglev represent a gradual performance progression from currently available Diesel and electric locomotives to advanced prime mover and electric motive power, and to the 300 mph performance of linear induction motors and frictionless magnetic suspension. Portraying this progression, Figure Chapter 4 -1 shows that Maglev completes a 50-mile simulated course (nonstop on straight track) in one-third the trip time of Accelerail 90.

Alignments and Station Locations

To create as realistic a scenario as possible for HSGT service, the study made general assumptions about alignments and station locations which allowed for evaluation of HSGT from a national perspective.[23]

With respect to alignments:

- **Accelerail** options were assumed to follow existing Amtrak routes or, if no direct Amtrak route presently exists, the most direct freight railroad mainline.
- Except in major urban areas where upgraded freight or commuter railroads could provide expeditious access to terminals, **New HSR** was provided with new alignments that would be as direct as possible within the constraints of cost-effectiveness. In the New York City area, with its ever-burgeoning commuter demands over existing routes, completely new alignments were posited.[24]
- **Maglev** was assumed to occupy new alignments that would be as direct as possible within the constraints of cost-effectiveness.

Obviously, future detailed studies of individual corridors will address a wider variety of potential alignments than this nationwide study, with its many cases, could treat. From such advanced work, better alignment possibilities will doubtless emerge. With respect to Accelerail, Amtrak's existing route structure may not everywhere provide the optimal available base for future passenger operations. Moreover, for each New HSR and Maglev corridor, multiple analytical iterations—involving alternative routes, trip times, demands, revenues, and costs—may be prerequisite to fully informed decisions on the economics of railway location.

With regard to station locations:

- Each major city was assumed to have a station in the **city center**, except where alignment considerations dictated otherwise (e.g., Albany/ Rensselaer was retained in the Accelerail options for the Empire Corridor).
- Additional **"Beltway"-type stations** were provided in major metropolitan areas to reduce access times and expand HSGT's market reach to the suburbs.

[23] Site-specific planning for HSGT systems will, of course, reflect detailed knowledge of regional, State, and local facts, needs, and concerns that were beyond the scope of this report.
[24] This, too, would be subject to very complex and expensive study at the local level.

- For analytical purposes only, the study eliminated existing stations that served fewer than 20,000 passengers per year. Certain other stations were assumed to be consolidated with larger, nearby stations that could provide adequate service. The ultimate decisions on station locations will, of course, rest with the private/public HSGT partnerships.
- In accordance with the intent of ISTEA to create a seamless transportation network, the study actively sought to incorporate new airport stations along corridors. New HSR and Maglev alignments were specifically designed to serve important airports wherever HSGT trip-time goals permitted; Accelerail cases also included airport stations wherever existing rail alignments passed through or adjacent to airport properties.[25]

Operating Assumptions

Line-haul trip times reflect the simulated performance of the technological options, as specified in Table Chapter 4 -5, over the applicable alignments for each illustrative corridor. Trip times for origin-destination markets also reflect dwell time for stops at intermediate points (adjusted for a likely service mix of non-stop or limited stop trains), and a five percent pad commonly used in developing transportation schedules to compensate for operational uncertainties, disruptions, and the like. Line-haul times for HSGT were assumed to show no change over the planning period.

Train frequencies resulted from iteration: they were specified as inputs to the demand model, compared with ridership results throughout the planning period, and adjusted to adhere to an assumed maximum 60 percent load factor[26] for the busiest link in each corridor. Under no circumstances, however, were departure frequencies allowed to fall below six daily.

Express service was assumed to be provided where warranted, particularly in the highest-density markets. Thus, not all trains would stop at all stations.

Turnaround times. The minimum turnaround time at terminals for trainsets in active service was assumed to be a half-hour.

[25] In the Chicago Hub, O'Hare Airport would be such an important traffic generator that Accelerail service was assumed to extend to it from both Detroit and St. Louis, through Union Station.
[26] This 60 percent would be an average over the entire year and acknowledges that the busiest link will be saturated at peak times.

Fare-Setting

HSGT fares were normally set to maximize net revenue to the HSGT operator. For major city-pair markets in each corridor, the analysis identified HSGT's prime competitor mode (the potential source of most HSGT revenues), set HSGT fares as percentages of the prime competitor's fares (e.g., "75 percent of air"), developed demand results for a spectrum of possible fare levels, and selected the fare that would provide the highest operating surplus. Fares for smaller markets were derived from those for major markets.

In shorter rail corridors (under 150 miles) in which Amtrak currently provides relatively high frequencies and generates significant rail traffic,[27] conventional rail would be the prime "competitor"; normal fare-setting procedures would have raised HSGT fares to more than double the 1993 fare levels in real terms. While future revenues would have been maximized, ridership would have fallen below the expected growth for conventional Amtrak service. It is unlikely that State and local governments would consent to invest in options that more than double fares and carry fewer riders than Amtrak does today. As a result, in these few markets, this study capped HSGT fares at 180 percent of Amtrak's 1993 fares.

Table Chapter 4 -6 summarizes the basic fare-setting assumptions by corridor and technology. As with the other modes, [28] HSGT fares were assumed to remain constant throughout the planning period.

Institutional Assumptions

Some of the HSGT options—particularly those involving Accelerail-type technologies—may entail ownership/operation structures with more than one participant. For the sake of simplicity, the study characterized the two main participants[29] as an independent HSGT entity and a generic, large (Class I) freight railroad. This section characterizes the projected HSGT entity and describes the assumed relationships between the owning/operating partners.

Table Chapter 4 -6
Fare Setting for the HSGT Cases

	Fares by Option Expressed as Percentages of Primary Competing Mode (R = Rail, A = Air) (Shading indicates that the case was not analyzed for inclusion in this report.)

[27] For example, San Diego-Los Angeles.
[28] See under "Fares and Perceived Costs," page 4-4.
[29] This institutional categorization deals with the operating entities and omits the important relationships with the public sponsors and other public and private partners in HSGT.

Corridor	Accelerail 90	Accelerail 110	Accelerail 125F	Accelerail 125E	Accelerail 150F	Accelerail 150E	New HSR	Maglev
California North/South	85 (A)	85 (A)	85 (A)	85 (A)	85 (A)	85 (A)	90 (A)	110 (A)
California South	150 (R)	155 (R)	155 (R)	155 (R)			160 (R)	165 (R)
Chicago Hub Network	same as spokes (shown below)							
Chicago - Detroit	145 (R)	170 (R)	70 (A)	70 (A)	75 (A)	75 (A)	95 (A)	130 (A)
Chicago - St. Louis	125 (R)	140 (R)	80 (A)	80 (A)	80 (A)	80 (A)	95 (A)	125 (A)
Florida	130 (R)	140 (R)	70 (A)	70 (A)			85 (A)	105 (A)
Northeast Corridor							70 (A)	75 (A)
Pacific Northwest Corridor	45 (A)	55 (A)	55 (A)	55 (A)			70 (A)	85 (A)
Texas Triangle	75 (A)	75 (A)	75 (A)	75 (A)	80 (A)	80 (A)	95 (A)	125 (A)
Empire Corridor [30]			30 (A)				45 (A)	45 (A)
Southeast Corridor[30]		30 (A)					45 (A)	45 (A)

The HSGT Operating Entity

The entity that operates HSGT services was assumed to be a private, for-profit concern specifically set up to efficiently and effectively manage a single corridor—or group of related corridors[31]—with the focused management, marketing prowess, operational responsiveness, efficient procedures, and customer-service orientation characteristic of a very successful, entrepreneurial small business. In reality, such an entity could be a highly independent, market-oriented, compact, aggressive subsidiary or business unit of a larger private or mixed private/public company (such as Amtrak), or a State, regional, or local government-sponsored authority.

Owner/Operator Paradigms

To best reflect the scope of the HSGT entity's ownership and operating responsibilities, the study developed—and applied to identifiable segments of each corridor—three basic institutional paradigms[32]:

- "TENANT"—The entire segment is owned and maintained by the freight railroad; the HSGT entity, as tenant, reimburses the landlord

[30] Treated as an extension of the Northeast Corridor; see Chapter 8. Percentages shown are for trips wholly within the extensions; trips involving Northeast Corridor service will carry higher percentages.
[31] E.g., the Chicago Hub network as considered in this report.
[32] The operating expense model applies these paradigms on a route segment basis. Thus, for example, the Chicago-Detroit corridor, now partially owned by Amtrak, has both a "Tenant" and a "Landlord" segment.

railroad for the incremental expenses occasioned by the presence of HSGT, plus a management fee.[33] This is the most common paradigm for the Accelerail options.

- "LANDLORD"—The HSGT entity owns and maintains the track in the segment, charging the freight railroad (or a commuter rail service) for its use. In this study, the "landlord" paradigm applies only where a route segment currently belongs to an intercity railroad passenger operator.[34]
- "NEW RIGHT-OF-WAY"—The entire segment is owned and maintained by HSGT for its exclusive use. This paradigm applies to Maglev lines in their entirely, and to the bulk of New HSR route mileage.[35]

Cooperation with Freight Railroads

Successful implementation of the "tenant" paradigm requires, and this report assumes, the cooperation of the freight railroad landlord. The Department recognizes that the freight railroads—in pursuing their self-evident business interests, which serve the Nation's critical freight transportation needs—have thus far adopted widely varying policies toward HSGT development.[36] However, the potential benefits of HSGT to freight railroads in site-specific instances, and the current cooperation of the railroad companies in development of the Southeast and Pacific Northwest corridors, offer both theoretical and practical justification for assuming carrier cooperation in the Accelerail options.

Accordingly, the study includes the following assumptions affecting the relationships between HSGT entities and freight railroads:

- **Assumption: Liability.** Currently, liability represents a challenge to be met in HSGT development. An equitable assignment of responsibility for HSGT liability claims will be a prerequisite to effecting the "tenant"-type institutional paradigm. The study assumed that these liability issues would be resolved and estimated the HSGT entity's liability expenses on a speed-adjusted passenger-mile basis reflecting the experience of other passenger transport providers. It should be noted

[33] See Chapter 5. The main incremental expenses are maintenance of way and dispatching. The management fee is 20 percent on labor and 3 percent on materials.
[34] For example, in the Chicago—Detroit corridor, the "landlord" paradigm applies to the segment currently owned by Amtrak and the "tenant" paradigm applies elsewhere.
[35] But see earlier in this chapter regarding assumptions for New HSR approaches to major cities.
[36] See, for example, Daniel L. Roth, "Incremental High-Speed Rail Issues," in *Transportation Quarterly*, Vol. 49, No. 2, Spring 1995, p. 66. These carrier views were expressed at a November 1994 FRA public meeting on this study, as well as at subsequent conferences on freight railroads and HSGT sponsored by *Railway Age.*

that this is an extremely controversial issue with freight railroads and this assumption may underestimate final costs.

- **Assumption: Right-of-way.** The analysis assumed that existing freight railroad rights-of-way would remain the property of the current owners and that access to these rights-of-way would be available for Accelerail (and for New HSR where necessary).[37]

- **Assumption: Investment programs.** The HSGT entity and its non-railroad partners would bear the entire capital costs of the requisite improvements to the freight railroad.[38] These improvements would include sufficient capacity to accommodate reliably both freight traffic (including a one-fifth increase in train frequencies) and the superimposed HSGT traffic.

  In addition, as described in Chapter 5, the HSGT project would include the capital cost of making an assumed proportion of the freight railroad's locomotive fleet compatible with the train control system. Any differences between the costs assumed herein for locomotive compatibility, those identified by the railroad, and those which the other HSGT partners would be willing to absorb, would fall under the rubric of items left to negotiation (see below).

- **Assumption: Payments to the freight railroad.** The payment for incremental purchased services (described above under the "tenant" paradigm) would be the **only** major operating expense due from the HSGT entity to the freight railroad landlord.

- **Items left to negotiation.** This nationwide analysis relegated a number of items to detailed negotiations between the railroads, the HSGT entities, and other project partners. Examples of these items include:

  — Valuation of the benefits to the railroad from construction of HSGT improvements;

  — Resolution of any differences over the responsibility for freight locomotive fleet compatibility with HSGT;

[37] Although a State may, in specific instances, wish to negotiate the purchase of Accelerail right-of-way from a willing freight railroad, the case studies in this report did not incorporate such an eventuality.
[38] This assumption prevails even though the freight railroad operation may also stand to gain from some HSGT project elements. As noted below, any tangible benefits of Accelerail to the freight railroad would inevitably enter into the latter's partnership negotiations and financial arrangements with the public HSGT sponsors and the HSGT entity.

— Any trackage rights payments (i.e., rentals and profits over and above purchased services and management fees);

— Any line purchase or relocation costs resulting from detailed studies and negotiations;

— Any incentive payments for on-time performance (in keeping with Amtrak precedents);

— Resolution mechanisms for operating conflicts; and

— Valuation of fully allocated costs associated with increased usage of freight infrastructure.

CHAPTER 5
METHODOLOGY—SYSTEM REQUIREMENTS AND PERFORMANCE

This chapter presents the methodologies and specific assumptions for the analysis of system requirements and performance of the HSGT cases. The four main analytical components are capital investments, travel demand and revenues, operating and maintenance (O&M) expenses, and ancillary activities.

CAPITAL INVESTMENTS

Building on the system design assumptions outlined in Chapter 4, the capital investment requirements for an HSGT case fall into four broad categories:

1. Initial investment in fixed plant;
2. Initial investment in vehicles;
3. Continuing investment in vehicles; and
4. Continuing investment in fixed plant

Initial Investments

Initial investments include all fixed plant, rolling stock, and related equipment and facilities necessary to operate and maintain the HSGT system at its inception.

Initial Fixed Plant Costs

Initial fixed plant requirements for Accelerail cases came primarily from a review of track charts and other secondary sources.[1] For New HSR and Maglev, the new rights-of-way were superimposed on geographic information system maps. In both cases, the research led to application of standard unit costs to the identified quantities and types of work.

Major components of initial fixed plant costs, together with key assumptions and procedures governing the costing effort, are summarized below.

Right-of-way purchase and preparation costs figured into the estimates for New HSR and Maglev because they involve new right-of-way. Such costs entered into Accelerail estimates only for curve realignments outside the existing right-of-way.

Realignments were treated as follows:

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[1] The scope of the capital costing effort did not allow for the illustrative corridors to undergo on-site inspection especially for this study.

Technology:	Accelerail 90	Accelerail 110, 125, 150	New HSR	Maglev
Treatment:	No realignments outside right-of-way	Modest realignments, where feasible and requiring no extraordinary construction or relocations	Does not apply—new rights-of-way[2]	

Track capacity additions (applies to Accelerail only). New sidings, turnouts, crossovers, double track sections, and reverse-signaling provisions were specified for existing freight railroads, in order to accommodate—without adverse impact—freight train frequencies one-fifth greater than those of today, along with projected HSGT trains.

New track construction (New HSR and Maglev). New HSR track was assumed to be constructed to world-class (e.g., French, German, or Japanese) standards for 200 mph permanent way. Maglev guideway reflected the system design concept for U.S. Maglev as described in the report on the National Maglev Initiative (NMI), with some design modifications based on subsequent research and made in consultation with such NMI participants as the U.S. Army Corps of Engineers. Both New HSR and Maglev were assumed to be essentially double-tracked in the Northeast and California[3] corridors, but lower prospective traffic densities in most other corridors permitted the frequent use of single track with long passing sidings.

Track structure improvements. Accelerail 150 options assumed a rebuilding of the track to standards approaching those of New HSR, including concrete ties. The other Accelerail options presupposed that—

- The freight railroads would be in a state of good repair at the inception of HSGT projects—in particular, the existing rail would be suitable for the higher speeds;
- The HSGT project would "line and surface" (bring to strict geometric tolerances) all mainline track;
- Ties, other track materials, and ballast would be selectively renewed, at a rate requisite to the speed level;
- Track undercutting, ballast cleaning, and drainage improvements would occur for Accelerail 110 and 125; and

[2] Brief segments of New HSR, primarily in approaches to large cities, would make use of existing railroad rights-of-way and were treated (in this and analogous design issues) similarly to higher-speed Accelerail options.
[3] Los Angeles—Bay Area segment only.

- The condition of the track upon completion of the upgrading would be consistently maintained thereafter. [4]

Train control systems. New HSR and Maglev would have all-new, state-of-the-art train control systems. The Accelerail options were estimated with train control systems providing speed and authority enforcement.

The train control systems for Accelerail will necessitate that freight railroads' locomotives be equipped with cab displays. These retrofits were estimated based on each railroad's fleet size and its route-mileage: the shorter the railroad, the higher the percentage of locomotives assumed to require cab displays. (See Table Chapter 5 -1.) As discussed in Chapter 4, any remaining differences over the extent and responsibility for locomotive modifications would be left to negotiations between the railroad and other Accelerail partners.

Table Chapter 5 -1
Assumed Percent of Freight Locomotives Retrofitted with Cab Displays by Railroad Size

Total Route-Miles of the Freight Railroad	Percent of Freight Railroad's Locomotives Assumed To Be Retrofitted
0—2,000	100%
2,001—5,000	75%
5,001—10,000	50%
10,001—15,000	25%
15,001 and above	15%

As added safety precautions for the mixed-use Accelerail environment, the estimates also included shifted load detectors and additional electrically locked switches.

Electrification. New HSR and Maglev lines would be fully electrified. The Accelerail 125 and 150 electrified cases were assumed to have modern, unobtrusive, European-style electrification systems similar to that approved for installation between New Haven and Boston.[5] Electric propulsion was treated as an "overlay" for cost estimating because the same alignments were used as in the nonelectrified cases. The overlay consists of adding the required power supply system (substations) and delivery system (catenary) to the candidate rail corridor, and providing the modifications to the signal systems and clearances required to accommodate electrification.

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[4] The costs of such a program were indeed charged against each case—see below under O&M expenses.

[5] Federal Railroad Administration, *Record of Decision—Final Environmental Impact Statement/Report and 4(f) Statement—Northeast Corridor Improvement Project Electrification—New Haven, Connecticut to Boston, Massachusetts,* May 1995.

Grade Crossings and Fencing. New HSR and Maglev would have no highway/railroad grade crossings. Treatment of crossings on Accelerail lines adhered strictly to the Department's Action Plan for Highway-Rail Crossing Safety[6] and assumed improvements for public and private crossings that suit the planned operating speed over each crossing, rather than the top speed of the technology. The distribution of crossings by treatment at each operating speed level appears in Table Chapter 5 -2.

Table Chapter 5 -2
Assumed Treatment of Grade Crossings

Operating speed over crossing (mph)		Percentage of crossings	Percentage of crossings at each speed level improved by—			
From	**To**	**retaining existing warning levels**	**Installing or upgrading flasher-gate systems**	**Providing positive barriers against intrusion**	**Separating**	**Closing**
PUBLIC CROSSINGS						
0	79	65%	10%			25%
80	110		65%		10%	25%
111	125			50%	25%	25%
126	and up				75%	25%
PRIVATE CROSSINGS						
0	79	75%				25%
80	110		60%			40%
111	125			30%	30%	40%
126	and up				60%	40%

The New HSR and Maglev options were assumed to be completely fenced, for protection both of the railroad and of would-be trespassers. Fencing was installed in the Accelerail cases at a coverage rate that was dependent on the maximum speed operated over each segment.

Station treatments differed as between newly built and existing facilities:

- Each **new station**—built from scratch on New HSR or Maglev lines or added to Accelerail systems—was sized, and its high-level platform and track requirements were established, to accommodate its estimated volume of traffic for the Year 2020 (midpoint of the planning period).

[6] Federal Railroad Administration, Federal Highway Administration, Federal Transit Administration, National Highway Traffic Safety Administration, *Rail-Highway Crossing Safety Action Plan Support Proposals*, June 13, 1994, pp. 28-30.

Costs were developed on a per-square-foot basis reflecting similar construction.

- **Existing Accelerail stations** were assumed to be already adequately sized. High-level platforms, however, were estimated and charged to each case.

Other fixed facilities included:

- Maintenance-of-way bases (sited at regular intervals)[7];
- Storage yards (based on fleet size in each case); and
- Equipment maintenance/repair and service/inspection facilities. Each corridor (or group of corridors considered together) was assumed to have one maintenance/repair shop. In addition, each corridor **over 150 miles in length** was estimated to have a service/inspection facility at both endpoints.[8,9]

Contingency and Program Management. The following percentage markups of project cost provided an allowance for contingencies, design, and construction management:

	Upgrading of Existing Railroads (Mainly Accelerail)	**New Construction (Mainly Maglev and New HSR); also Accelerail electrification**
Contingencies	20%	25%
Design/construction management	10%	16%
Total allowance	30%	41%

Initial Vehicles

The required number of initial trainsets for a particular HSGT system[10] was determined to satisfy its estimated demand and service itineraries as of the year 2000, and through the early years of corridor development. Several factors influenced the number of trainsets required including forecast passenger demand, trip times, equipment turn times, and

[7] Lease costs for related movable equipment, both railborne (e.g. tamper) and highway (e.g. utility cranes, crew cab trucks), are included in operating and maintenance expenses.
[8] Up-to-date Amtrak maintenance/repair/service/inspection shops already exist at Washington and Boston, and non-Maglev corridors terminating in either of those two cities benefited from a consequent reduction in capital costs.
[9] Corridors less than 150 miles long (of which this report contains only one example, California South) were assumed to require only one service/inspection facility.
[10] See Chapter 4 for trainset composition.

maintenance cycling. The cost of a locomotive varied with technology and was determined based on recent procurements and estimates for development when necessary.

The cost of a passenger car depended largely on its interior configurations (e.g., coach, coach-café) and reflected recent procurements and the number of cars ordered.

Initial base costs ranged from $10 million per trainset for Accelerail 90 consists ($38,000 per seat) up to nearly $20 million per trainset for New HSR ($52,000 per seat). The estimated base cost for Maglev vehicles was approximately $12 million per two-car trainset ($80,000 per seat).

Continuing Investments

Continuing investments included all expenditures, other than annually recurring O&M expenses, that would be incurred after the inception of HSGT service for fixed plant, rolling stock, and related equipment and facilities. These ongoing investments would be necessary to maintain the high degree of operational reliability and service quality that would keep HSGT service marketable and commercially viable.

Continuing Vehicle Investments

Continuing investments in vehicles included the following items, for which the analysis projected expenditures in the specific years of incurrence:

- **Fleet expansion.** The number of required trainsets would increase over the study period (2000 —2040) with increases in demand. These additional trains were assumed to be purchased in the middle of each planning decade, or in some cases less frequently, in order to accommodate growth. In general, fleet expansion equipment orders would be for fewer units than the initial order.
- **Fleet replacement**. Assumed fleet life would be 20 years, at which time vehicles would be replaced in kind.
- **Fleet overhauls** were assumed to occur on a mileage-driven basis that would differ by technology, with work performed by outside contractors.

Equipment overhauls and equipment purchases, either to expand service or to replace older equipment, were treated as continuing investments in the year in which they would occur.

Continuing Fixed Facility Investments

For New HSR and any new construction under Accelerail options, the periodic replacement of major track and electric traction components (“program” track maintenance) was ascribed to particular years based on expected life cycles of the components.[11]

Continuing Investments for Maglev

For Maglev, continuing investments included fleet replacements and expansions only; vehicle overhauls and fixed facility program maintenance were subsumed in operating expenses.

Areas of Uncertainty in Capital Cost Projections

Beyond the requirement for intensive, site-specific engineering work as a prerequisite to implementing any HSGT corridor, two areas of uncertainty characterize the capital cost projections and emphasize the need for further detailed study of individual corridors.

Safety is a fundamental mission of the Department, and ongoing safety research and experience periodically necessitate reexamination and augmentation of the FRA’s railroad safety standards. To the extent that new safety regulations and guidelines impose costs not addressed in this report, the initial investment requirements will increase over the levels projected herein. On the other hand, the FRA’s Next Generation High-Speed Rail program is actively pursuing opportunities for technological developments that would enhance safety, lower capital and operating costs, and improve system performance. The net financial effect of all these ongoing activities is not susceptible to estimation at this time, nor is it included in the capital cost contingency factors.

TRAVEL DEMAND AND REVENUES

This section describes the methodology underlying the demand and revenue projections for each case.

Overview

The broad outlines of the demand methodology, as applied to each case, are as follows:

[11] For Accelerail options in general, this study did not determine the installation dates of the freight railroads’ track components, and “program” maintenance was treated as a separate, annualized element of maintenance-of-way expense.

Step 1: In the **absence** of HSGT, **project the likely traffic of the existing modes** for all city-pair markets in the forecast years.

- Air
- Auto
- Bus
- Conventional rail

↓

Step 2: Apply **diversion models** to each existing mode to develop the likely traffic levels contributed by that mode to an HSGT system.

↓

Step 3: Based on the proportions of diversion from other modes, develop **induced demands** for HSGT.

↓

Step 4: HSGT demand is the total of **diverted** plus **induced** demand, summed across all city pair markets served by the case.

↓

Step 5: HSGT passenger transportation revenue is the product of the demand times the assumed fares (separately calculated for business- and nonbusiness-purpose trips).

Step 1: Project Existing Modes Without HSGT

Air and auto projections made use of regression equations, while bus and rail projections incorporated a simple annual percentage increase assumption from a 1993 base, within the range established for auto and air.

Air Projections

A regression equation related air volumes in 1979, 1983, 1988, and 1993[12] to fares, distances, population, and per capita income. On the basis of this equation, assumed fares,

[12]Taken from the 10 percent sample of actual tickets sold by large airlines as compiled by the Research and Special Programs Administration (RSPA) of the Department. Minor adjustments were made to account for missing commuter airline trips and a small undercount. Base year traffic was extrapolated from the 10 percent sample for that year. For comparison purposes, actual total commuter airline trips for a city pair were obtained from RSPA. Given a situation when the extrapolated traffic for a city-pair appeared high/low in comparison with the actual commuter trips, an adjustment was made to the base traffic. The effects of such adjustments added 2.2 percent to total air traffic. All trip totals were then increased by 1.5 percent (3.7% -2.2%) to account

and applicable BEA population and income forecasts,[13] the model then developed air passenger growth factors for each city-pair market. Application of these growth factors to 1993 actual data yielded the presumed air traffic for the forecast years.

Auto Projections

No solid data base currently exists for auto traffic on a city-pair basis. Therefore, on the basis of observations of auto trips in 55 markets from previous detailed corridor studies, a model was developed to estimate existing and future auto traffic in 50- to 500-mile city-pair markets. The model calculates auto trips for any year as a function of—

- the combined personal income of the two cities;
- the distance separating the cities;
- the potential of one of the cities, due to its recreational infrastructure, to attract a high number of tourists; and
- whether or not competing, frequently operated rail service exists between the cities.

Conventional Rail Projections

"Conventional rail" means passenger train service of the type and frequency operated by Amtrak in the early 1990s. Amtrak city-pair ridership statistics were adjusted to remove local traffic,[14] then projected through the study period by applying the growth rates described in Chapter 4.

Bus Projections

Since the bus companies do not publish their city-pair ridership, the study estimated 1993 bus traffic from bus route frequencies, an average seat capacity of 45, and an assumed average load factor of 50 percent for corridor-type services.[15] A gravity model then estimated the number of bus passengers traveling to and from all city pairs (stops) within a route,[16] thus providing a base for forecasts.

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for the remainder of the ticket sample's shortage compared to Federal Aviation Administration enplanement data.

[13] See Chapter 4 for underlying assumptions and BEA forecasts.

[14] I.e., within CMSAs or MSAs and less than 50 miles; see Chapter 4.

[15] Thus a 45 seat bus is assumed to have 22.5 passengers, and this is multiplied by the bus frequency between the route endpoints. The 50 percent average load factor is based on a conversation with a bus industry expert.

[16] The gravity model calculates the number of intermediate stop passengers by using as explanatory variables the population and income for the "stop" areas (cities) and the distance between the stops.

Step 2: Apply Diversion Models

A set of diversion models—one for each mode and trip purpose—estimated the percentage of trips in each city-pair that HSGT would attract were it available. In this discussion, the "donor mode" is one of the existing modes as projected for the future, and the HSGT option is the recipient mode.

Each diversion model considers pairwise comparisons of the utility of HSGT versus that of the existing mode, as seen by business and nonbusiness travelers. If the perceived utilities are equal, then HSGT attracts 50 percent of the donor mode's passengers.

The diversion model equations include, as independent variables, the fares, trip times, and frequencies of the paired, competing modes. The coefficients used in these linear combinations depend on the donor mode and trip purpose; represent the relative value that travelers, who are using that mode for that purpose, attach to the attribute, e. g., "value of time"; and reflect structured interviews in which travelers expressed preferences between their habitual mode and alternatives characterized according to these attributes.

There are separate equations for business and nonbusiness trip purposes for each of the following five donor modes, for a total of ten[17] equations in all:

1. **Local air trips within a corridor ("Air O/D")—**the actual trip endpoints are both in the corridor
2. **Transfer air trips ("Air Transfer")—**the trip within the corridor forms part of a longer air trip
3. **Auto**
4. **Conventional Rail**[18]
5. **Bus**

For each donor mode and trip purpose, these equations calculate future market share percentages for HSGT by city pair. These percentages, when applied to the base trips projected by donor mode and trip purpose in the absence of HSGT, yield the ridership diverted to HSGT. Total HSGT ridership in a corridor thus aggregates the diverted ridership in all markets from all donor modes and trip purposes.

Step 3: Develop Induced Demand

Induced demand, which is totally new demand for travel created by the introduction of a new travel option, generates controversy owing to the paucity of corroborative historical

[17] Actually, the air and auto modes are further disaggregated, making a total of 16 equations.
[18] In markets where significant conventional rail service already exists, adjustments are made to account for trips which have already diverted to the existing rail service.

data, roadblocks to defining and quantifying such demand even where data exist, and methodological difficulties.[19]

Probable cause exists, however, for allowing for a modicum of induced demand in this analysis. Studies of the effects of introducing totally new transport capabilities (the jet in transatlantic travel, major additions to highway networks) suggest that up to 70 to 80 percent of demand can be termed "induced." More germane to HSGT, estimates of demand induced by Shinkansen lines in Japan range from 6 to 28 percent of total travel; the French National Railways claims that as of 1984, 16 percent of the traffic on the Paris-Lyon TGV line was induced.[20]

When Southwest Airlines entered the Baltimore/Washington—Cleveland market, its 81 percent fare cut caused traffic between all three Washington area airports and Cleveland to grow by 173 percent over the previous year's traffic. Determining how much of that was induced—**trips that would never have occurred without the "new service"**—exemplifies the problems bedeviling all induced demand projections. First, there would have been natural traffic growth due to improved national and local business conditions. Second, traffic would have been diverted from other airports—conceivably, even from as far away as Richmond, Harrisburg, Philadelphia, and New York. Third, the new fare (averaging $31) can be cheaper per mile than the perceived cost of driving assumed in this study, so that considerable auto traffic might have been diverted between very large catchment areas surrounding the two origins and destinations.[21] Only the residual, which cannot be readily calculated based on available data and techniques, would truly constitute induced demand.

Table Chapter 5 -3 shows the importance of induced demand in several HSGT corridor studies. Following the precedent set by the more cautious of those studies as well as transit

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[19] As the World Bank's railway advisor puts it:

> Beware of induced demand. Logically, if an entirely new option is available, at least some demand will occur that is entirely new and would only exist with the new mode. Common sense (unlike some models) suggests that, if all else is held constant, little new demand would actually result. Clearly, models that predict significant levels of induced demand must bear the burden of proof.—Louis S. Thompson, "Trapped in the Forecast: An Economic Field of Dreams," *Transportation Research News 165*, March-April 1993.

[20] Boon, Jones and Associates, Kingston, Ontario, *Induced Demand: Case Histories*, for National Maglev Initiative.

[21] To illustrate these last two factors: Baltimore-Washington International Airport—now a low-fare Mecca due to the presence of Southwest Airlines—in 1995 registered a growth of 114 percent in passengers originating in the District of Columbia, almost 90 percent from Virginia, and 80 percent from Southern Pennsylvania, according to the Baltimore Metropolitan Council.

Table Chapter 5 -3
Induced Demand in Other Corridor Studies[22]

L.A.—Las Vegas:	48%	New York—Montreal:	17%
Florida:	40%	Texas Triangle:	10%[23]
Pennsylvania:	None	Ohio:	6.8—7.6%
Detroit—Chicago:	10%	National Maglev Initiative	10% (baseline option)

industry experience, [24] this analysis assumed that **induced demand will equate to ten percent or less of the diverted traffic,** as detailed in Table Chapter 5 -4.

Table Chapter 5 -4
Assumptions on Induced Demand

Donor Mode	Induced HSGT Traffic as a Percentage of Traffic Diverted from Donor Mode
Air O/D	10%
Air Transfer	25% of 10%, or 2.5 percent
Auto	10%
Conventional Rail	At 50% diversion rates and above, a graduated scale of diversion starting at 0% and reaching 10% at the 100% diversion level

Steps 4 and 5: Total Demand and Transportation Revenue

The total HSGT travel for each case in each forecast year equates to the sum, across all city-pair markets in the corridor, of—

- Ridership diverted from each donor mode, by trip purpose, plus
- Induced ridership, expressed as a percentage markup over diverted traffic by donor mode and trip purpose.

Likewise, the passenger transportation revenue for each case summarizes, across all city-pairs—

- Diverted plus induced business-purpose trips, times the assumed HSGT business fare, plus

[22] Source: *In Pursuit of Speed***,** Transportation Research Board, Washington: 1991, p. 105; *Final Report on the National Maglev Initiative*, p. 3-4.
[23]This was for the initial Texas work. Subsequent efforts used a more complex method.
[24] Retrospectives on urban transit ridership (derived from reported information on selected systems) before and after the introduction of light or heavy rail to bus-only corridors show the following results, in terms of the ratios of induced to diverted travel:

- BART Transbay (1975): **12%**
- Euclid Line, San Diego Trolley (1987): **7%**
- MARTA East-West Line (1980): **17%**
- WMATA Van Ness Extension (1984): **13%**

- Diverted plus induced nonbusiness trips, times the assumed HSGT nonbusiness fare.

Passenger transportation revenue, plus income from ancillary activities, equals system revenues for each case.

OPERATING AND MAINTENANCE EXPENSES

The O&M expense model constituted a build-up costing approach. It analyzed the entire HSGT operation into major functions (e.g., transportation), subfunctions (e.g., train movement), and activities (e.g., train operators) so as to identify and estimate all the work elements necessary to conduct and perpetuate passenger transportation service. The objective was to develop a total O&M expense for each case by adding detailed estimates up a complex hierarchy. Table Chapter 5 -5 exemplifies the output of the model and shows the expense hierarchy at its highest levels of aggregation.

To accomplish this, the model incorporated a series of linked spreadsheets, comprising an ordered set of cost-estimating relationships (CERs), to project O&M expenses for a broad spectrum of HSGT systems. This method resulted in a set of CERs with the flexibility to estimate costs based on:

- the technology being modeled;
- the service operated—frequency, top speeds, and other characteristics;
- the physical characteristics of the infrastructure over which the service is operated;
- the ownership and operational responsibility for the infrastructure; and
- the management philosophy applied to develop the HSGT organization.

Within that characterization, the expense estimates assumed the continuation of existing rail passenger industry wage rates, ratios of supervisory and support personnel to on-site primary workers, and spans of control. The expenses do, however, reflect the efficiencies inherent in high-volume, high-frequency, high-speed operations with new equipment, new or refurbished infrastructures, and enhanced customer service levels.

Maglev's uniqueness necessitated careful consideration in the development of the operating expense model. Not only does the technology depart from the steel-wheel-on-steel-rail norm of the other options, but no example of revenue intercity corridor service yet exists anywhere in the world. Therefore, the Maglev O&M expense estimates incorporated specialized CERs for such technology-specific functions as maintenance of equipment and maintenance of way, while such other functions as stations and train crews received the same treatment as for Accelerail and New HSR.

Table Chapter 5 -5: Example of O&M Model Output for a Typical Case[25]
(Year 2020; Amounts in Dollars)

Account Number	Description	Labor Costs	Energy	Other Materials	Purchased Services	Total O&M Expense
1000	**MAINTENANCE OF WAY**	**606,855**	**0**	**44,449**	**5,410,681**	**6,061,985**
1200	Permanent way maintenance - Inspection and Repair	383,323	0	6,881	2,154,047	2,544,251
1300	Permanent way program maintenance	2,837	0	23,917	2,878,329	2,905,083
1400	Major structures maintenance	0	0	0	70,409	70,409
1600	Electric traction maintenance	0	0	0	0	0
1800	Signals and communications maintenance	117,138	0	9,725	306,121	432,985
1900	M-O-W facilities operating overhead and maintenance	103,558	0	3,926	1,775	109,259
2000	**MAINTENANCE OF EQUIPMENT**	**4,587,429**	**7,149**	**782,296**	**4,297,848**	**9,674,722**
2300	Short turnaround cleaning	0	3,805	94,182	937,114	1,035,101
2500	Service and inspection	40,371	3,344	253,183	2,725,370	3,022,267
2700	Maintenance and repair	4,223,812	0	418,993	0	4,642,806
2900	M-O-E buildings operating overhead and maintenance	323,245	0	15,938	635,365	974,548
3000	**TRANSPORTATION**	**11,833,937**	**4,250,808**	**11,050**	**1,791,560**	**17,887,354**
3300	Superintendence and dispatching	335,454	0	11,050	1,791,560	2,138,064
3500	Train movement	10,513,055	4,215,619	0	0	14,728,674
3700	Yard operations	985,428	35,189	0	0	1,020,617
3900	Transportation facilities operating overhead and maintenance	0	0	0	0	0
4000	**PASSENGER TRAFFIC AND SERVICES**	**8,181,371**	**0**	**437,365**	**11,508,978**	**20,127,714**
4200	Marketing, service design, and pricing	1,834,621	0	263,589	0	2,098,210
4300	Information, reservations, and ticketing	921,054	0	15,084	9,111,166	10,047,303
4500	Baggage services	65,557	0	280	0	65,837
4600	Station operations and maintenance	0	0	0	185,676	185,676
4800	On-board services	4,077,521	0	116,163	2,212,137	6,405,821
4900	Station overhead	1,282,617	0	42,250	0	1,324,867
5000	**GENERAL AND ADMINISTRATIVE**	**6,343,603**	**0**	**690,569**	**11,540,683**	**18,574,855**
5200	General and administrative management	3,582,502	0	145,392	0	3,727,894
5300	Personnel	590,146	0	17,940	0	608,086
5400	Procurement	667,122	0	21,450	0	688,572
5500	Financial management	1,038,717	0	38,476	425,608	1,502,801
5600	Security	280,708	0	461,189	4,552,157	5,294,054
5700	Insurance and liability	184,408	0	6,122	5,845,109	6,035,639
5800	Taxes	0	0	0	0	0
5900	G&A facility operating overheads and maintenance	0	0	0	717,808	717,808
TOTAL		**31,553,194**	**4,257,957**	**1,965,730**	**34,549,750**	**72,326,631**

The following assumptions underlie the operating expenses for this study.

[25] “Tenant” Paradigm. **This table is provided for insight into the overall workings of the model rather than for the sake of the individual numbers.** A “zero” (or very small amount) in a cell does not necessarily mean the item is missing from (or underestimated in) the calculation. For instance, many energy costs are included in “purchased services” and certain overheads are dealt with elsewhere in the model than in the “overhead” accounts (1900, 2900, etc.).

Maintenance of Way

Incremental costing. In Accelerail cases[26] involving intercity passenger operations over a freight railroad landlord, the expense model estimated the freight railroad's track maintenance expenses both "with" and "without" the superimposed passenger service and assumed that the passenger operator would pay for the increment[27] as a "purchased service." Since the scope of the study did not allow for detailed engineering inspection of the existing routes, the model assumed a generic freight railroad based on typical conditions for principal main lines in the U.S. and calculated the baseline expenses ("without" HSGT) accordingly. The generic freight railroad was assumed always to be in good repair—i.e., with no deferred maintenance at any time. The assumed standards for the improved railroad ("with" HSGT) varied with the technological option and the assumed capital investments.

HSGT as Landlord. Where the HSGT operator would be the landlord, having freight or commuter tenants, this study assumed that the HSGT landlord would recover, with neither deficit, surplus, nor management fee, all incremental costs occasioned by the presence of tenant services (e.g., for track maintenance due to the presence of freight).[28] An HSGT landlord situation only occurred where an intercity right-of-way currently belongs to Amtrak—specifically, in the Northeast Corridor and in a portion of the Chicago—Detroit corridor.

Maintenance of Equipment

The assumed nature and frequency of equipment maintenance tasks governed the related O&M expenses. Table Chapter 5 -6 summarizes these cycles for the Accelerail and New HSR options.

Transportation

Incremental costing. Wherever intercity passenger operations would take place over a line owned by a freight railroad, the expense model estimated, and charged to the HSGT system, the incremental transportation superintendence and dispatching expenses to be borne by the railroad landlord.

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[26] Also in New HSR cases to the extent that they rely on existing railroads for access to city centers.
[27] Plus a 20 percent management fee on direct labor and three percent on materials.
[28] To the extent the HSGT landlord can exact payment from its tenant(s) of a portion of its fixed overhead costs, the landlord's operating results will improve over those shown here. Conversely, to the extent the tenant's payment to the HSGT landlord falls short of full incremental costs, the HSGT operator's results will suffer.

Table Chapter 5 -6
Equipment Maintenance Cycles for Steel-Wheel Options

Equipment Maintenance Task	Assumed Frequency
Interior cleaning	Each trip turnaround, in stations; daily at service/inspection facility for more time-consuming work
Exterior cleaning	Daily
Service and inspection	Each trip turnaround, in stations; daily at service/inspection facility for more time-consuming work
Periodic maintenance and repair	60-day and 6-month cycles, based on the nature of the required work
Running repairs	As needed
Overhauls	Every 1.5 million miles of revenue service

Trainset crew sizing. Consistent with emerging arrangements at Amtrak stations, ticket control was assumed to be by means of a farecard-type system at stations, all of which would have high-level platforms allowing easy access to trains. Nevertheless, the study assigned a three-person trainset crew—one operator ("engineer"), one conductor, and one customer service representative[29]—to all trains of six cars or less. This is in addition to personnel operating cafés (see under "On-Board Service," below).

In the rare instances[30] in which traffic densities called for trains with seven cars or more, the model added a second customer service representative (for a total of four trainset crew members) to assist the greater number of passengers.[31]

Passenger Traffic and Services

Information, reservations, and ticketing assumptions include:

- All trains will be space-controlled: while the HSGT operator will not require **advance** reservations, it will sell tickets only up to the seating capacity of each train.
- Twenty percent of passengers will arrive at the station without an **advance** reservation.
- Of the advance-reserving passengers, about one-third will reserve and purchase through travel agents at a ten percent commission, while two-

[29] Customer service representatives are accounted for under "passenger traffic and services/on-board services."
[30] E.g., in the Northeast Corridor New HSR case.
[31] This approximates the train crew-to-passenger ratios of the French National Railways for its TGV services.

thirds will reserve and purchase through the HSGT operator's own system.

Baggage service. In keeping with the precedent set by Amtrak's Metroliners and VIA's Canadian corridor services, the HSGT system was assumed to offer no checked baggage service. The relatively short distances involved, the availability of ample luggage storage space on trains, and the high capital and operating costs of checked baggage service called for this assumption. The model did allow for platform attendants to assist passengers needing assistance with their hand luggage, and rental luggage carts would be available.

On-board services. The study assumed that food and soft-drink service would occur at no direct cost[32] to, and with no revenue production for, the HSGT operator. This could be accomplished by developing a labor/management partnership to streamline Amtrak's existing staffing and commissary arrangements, by contracting out the cafés, by selectively raising prices, or by other means.

General and Administrative Expenses

Insurance and liability. Expenses for insurance and liability reflected the experience of airlines, commuter rail operators, and Amtrak on a per-passenger mile basis, adjusted for both speed and the overall scale of the corridor operation.[33]

Taxes. As described in Chapter 4, the O&M expense projections do not include property or income tax payments in view of the private/public partnership arrangement underlying the HSGT project.[34]

ANCILLARY ACTIVITIES

Intercity passenger carriers typically engage in activities that are ancillary to the basic movement of people, that enhance the quality of service, that are typically priced on a pay-as-you-go basis, and that often yield profits. This study modeled these ancillary activities and included them in the system requirements and performance of the cases. Depending on the case, the total income from ancillary activities amounted to between three and ten percent of system revenues.

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[32] The HSGT operator would absorb the cost of the revenue transportation space lost due to provision of cafés.
[33] The model typically returns costs of one to two cents per passenger-mile for this activity.
[34] The precise tax arrangements and implications will, of course, require further study and negotiation during the development of individual corridor partnerships.

Categories of Ancillary Activities

For purposes of this report ancillary activities fall into three categories: passenger-, commerce-, and facility-dependent activities. These categories are defined as follows:

Passenger-dependent activities involve the purchase of optional goods and services by passengers above and beyond the fares they pay for intercity transportation. These revenues relate directly to the number of passengers carried. In addition to services and conveniences for travelers, this category also includes revenues from advertising placed in the HSGT system by other entities.

Commerce-dependent activities include use of HSGT for hauling commercial freight, especially overnight and expedited freight and mail. These revenues are affected by the volume of commerce between the cities along the right-of-way, and by competing modes for moving this traffic. For some Accelerail and New HSR systems, the passenger operator's freedom to earn some types of freight revenue may depend on negotiations with its freight railroad partners.

Facility-dependent revenues are the third component of ancillary activities. These revenues can include lease of access to right-of-way, co-development of station properties, and lease of facility space.

Analytical Treatment

The study applied four generic approaches to projecting the results of ancillary activities:

(1) In situations in which the HSGT operator would—without incurring any initial capital expenditure—receive an income stream (such as franchise fees) from a concessionaire, the projection showed an "income only" based on expected net receipts per passenger, per pound of package shipments, and the like.

(2) If the HSGT operator would need to make an initial capital investment prior to enjoying an income stream, as in the case of parking and station concessions, the projection included both "income and capital cost" in the years earned or expended. Initial investments were sized to meet year 2020 demand.

(3) If an ancillary activity's revenues would lend themselves to projection, but the recipient of those revenues (or the party responsible for their attendant expenses or capital costs) would be difficult to identify, then the analysis developed those revenues for information only and omitted them from the operating results.

(4) Facility-related activities were too site-specific for inclusion in the operating projections and received "qualitative" treatment. Nevertheless, they could theoretically provide a boost to HSGT implementation—for example, if a commercial power industry highly covets access to a specific right-of-way.

Table Chapter 5 -7 summarizes the contents and treatment of each category.

Table Chapter 5 -7
Overview of Ancillary Activities

Category	Includes	Treatment[35]
Passenger-dependent	• Advertising revenue • On-board alcoholic beverage service revenue • On-board phone, fax and entertainment • Station parking revenue • Station concessions revenue	• Income only • Income only • Income only • Income and capital cost • Income and capital cost
Commerce-dependent	• First-class mail; document and small parcel express • Package express • Expedited LTL	• Income only • Revenue only (for information only; no income included) • Revenue only (for information only; no income included)
Facility-dependent	• Right-of-way access for pipelines, power lines, fiber optics, air rights • Co-development • Station leases	• All qualitative

[35] In the balance of this report, ancillary income is included in system revenues, of which the ancillary portion is typically between three and ten percent. Ancillary capital costs are included in infrastructure investments.

CHAPTER 6
METHODOLOGY—
COMPARISONS OF BENEFITS AND COSTS

Chapter 3 describes the rationale for going beyond purely commercial considerations to compare the range of benefits and costs attributable to HSGT systems. The present chapter describes the methodologies on which the benefit/cost comparisons are based.

TYPES OF BENEFIT/COST COMPARISONS

The analysis provides for three approaches to comparing benefits and costs:

(1) Total benefits versus total costs

(2) Benefits to HSGT users versus costs borne by users

(3) Benefits to the public at large versus publicly-borne costs

Regardless of the approach employed, the comparison of benefits with costs takes two basic forms: a subtraction (benefits less costs) and a ratio (benefits divided by costs).

The latter two approaches make use of subsets of "total benefits" and "total costs." Tables 6-1 through 6-3 present the constituents of each of these three approaches.

Table Chapter 6 -1

Total Benefits Versus Total Costs	
Types of Benefits and Costs	***Related Analytical Components***
Total Benefits:	
Benefits to HSGT Users:	
Benefits for Which HSGT Users Pay Directly....	**Equates to System Revenues (See Chapter 5)**
Benefits for Which HSGT Users Do Not Pay Directly	**Equates to Users' Consumer Surplus (Described in This Chapter)**
Benefits to the Public at Large:	
Airport Congestion Delay Savings	**Described in This Chapter**
Highway Congestion Delay Savings	**Described in This Chapter**
Emissions Savings	**Described in This Chapter**
Total Costs:	
Initial Investment..	**See Chapter 5**
Operating and Maintenance Expense...........................	**See Chapter 5**
Continuing Investments	**See Chapter 5**

Chapter 3 explains how the comparison of total benefits with total costs (Table Chapter 6 -1) enters into the "partnership potential" determination as formulated for this report. However, further benefit/cost comparisons may be of interest to the public and its responsible officials. Specifically, a comparison of the benefits to HSGT users with the costs borne by those users (Table Chapter 6 -2) reveals the relative importance of the users' consumer surplus, for which—by definition—they pay nothing directly.[1]

Table Chapter 6 -2

Benefits to HSGT Users Versus Costs Borne by Users	
Types of Benefits and Costs	***Related Analytical Components***
Benefits to HSGT Users:	
Benefits for Which HSGT Users Pay Directly....	**Equates to System Revenues (See Chapter 5)**
Benefits for Which HSGT Users Do Not Pay Directly	**Equates to Users' Consumer Surplus (Described in This Chapter)**
Costs Borne by Users	**Equates to System Revenues (See Chapter 5)**

By the same token, a comparison of benefits to the public at large with publicly-borne costs (Table Chapter 6 -3) provides additional insights on the value of the public investment.

Table Chapter 6 -3

Benefits to the Public at Large Versus Publicly-Borne Costs	
Types of Benefits and Costs	***Related Analytical Components***
Benefits to the Public at Large:	
Airport Congestion Delay Savings	**Described in This Chapter**
Highway Congestion Delay Savings....................	**Described in This Chapter**
Emissions Savings	**Described in This Chapter**
Publicly-Borne Costs...	**Equates to Total Costs Less Costs Borne by Users (i.e., in practical terms, Total Costs Less System Revenues)(See Chapter 5)**

In most (but not all) illustrative cases, as detailed in Chapter 7, the comparison of benefits to the public at large with publicly-borne costs tends to portray HSGT less favorably than does the comparison of total benefits with total costs. This pattern essentially reflects the absence of the users' consumer surplus from the benefits to the public at large, and its inclusion in total

[1] In this comparison, HSGT users are treated as users only, and not as taxpayers. That is, the indirect payments that users may make (in absorbing, via taxes, a portion of the public investment in HSGT) do not figure in the equation.

benefits. In economic terms, to the extent that the publicly-borne costs exceed the benefits to the public at large in a given case, the consumer surplus may be regarded as a subsidy enjoyed by the users.

"TOTAL BENEFITS" AND "OTHER IMPACTS"

The short-list of "total benefits" in Table Chapter 6 -1 resulted from a process of elimination, in which potentially includable benefits of HSGT had to satisfy all the following characteristics. Items lacking one or more of these characteristics fell under the rubric of "other impacts" and did not influence the quantitative results of the study.

Immediately quantifiable in practical terms: Within the scope of a nationwide study, data had to be available at a sufficient level of detail, and a straightforward methodology with broadly acceptable assumptions had to be developed, to make the item susceptible to estimation **for this report**. For example, many environmental/energy items (as well as benefits from improvements to commuter service) would theoretically lend themselves to quantification, but only in light of exhaustive, site-specific data gathered at the State and local level.

Monetizable: The item had to lend itself to expression in dollar terms, also in a straightforward manner.

Not duplicative: The item could not duplicate any other element of total benefits. To allow such duplication would result in a double counting of benefits, thereby skewing the results of the study. For example, total benefits could not legitimately include **both** reductions in congestion-driven airport delay costs to airlines and travelers **and** the value of deferred airport expansions, since these are two ways of measuring the same effect.[2]

Not a transfer effect: The item could not represent a reallocation of infrastructure investments and economic benefits from one geographic area or type of project to another. While such transfers might be of interest to the recipients at the State or local level, they cannot legitimately enter into total benefits from a national perspective. Typical transfers would include the economic multiplier effects of HSGT construction, operations, and station area development.

These criteria pertain specifically to a nationwide study at the Federal level. States may develop a different calculus of benefits because they will have access to much more detailed, corridor-specific information, because their priorities will reflect regional concerns, and because they may enjoy their own local financing sources.

Table Chapter 6 -4 presents the results of this process of elimination. The following sections present the methodologies for estimating the analytical components of total benefits that Chapter

[2] The same was true of highway delay cost reductions and deferred highway expansions.

Table Chapter 6 -4
Development of Components of Total Benefits

Components	Criteria for Inclusion in Total Benefits (• means criterion was met. All criteria had to be met for inclusion in Total Benefits.)			
	Quantifiable	Monetizable[3]	Not duplicative	Not a transfer
Total Benefits				
System Revenues	•	•	•	•
Users' Consumer Surplus	•	•	•	•
Benefits to the Public at Large:				
Airport congestion delay savings	•	•	•	•
Highway congestion delay savings	•	•	•	•
Emissions savings	•	•	•	•
Other Impacts				
Transportation Items:				
Airport investment deferrals	•	•		•
Highway investment deferrals	•	•		•
Commuter rail travel efficiency benefits			•	•
Transportation safety improvements			•	•
Economic Development Items:				
HSGT construction effects	•	•	•	
HSGT operations effects	•	•	•	
Station development effects	•	•	•	
Growth of American HSGT supply industry			•	•
Environmental/Energy Items:				
Noise			•	•
Water quality			•	•
Land consumption			•	•
Community disruption			•	•
Endangered species habitat			•	•
Wetlands			•	•

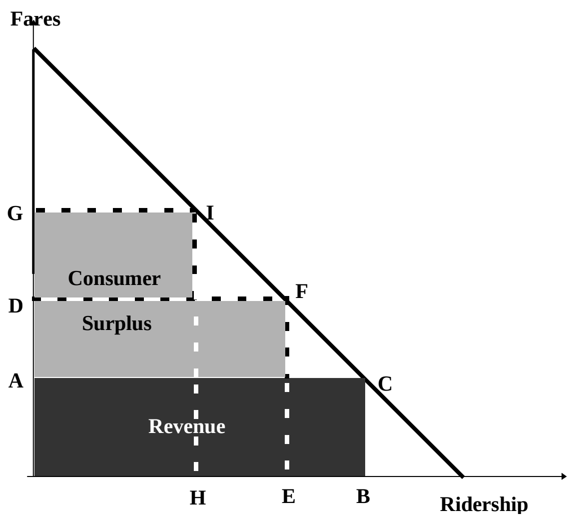
[3] If an item was not quantifiable, this table regards it as not monetizable.

Energy savings	•	•		•

5 does not treat: the users' consumer surplus and the benefits to the public at large. Finally, the chapter provides background information on "other impacts" that might be ascribed to HSGT.

USERS' CONSUMER SURPLUS

Figure Chapter 6 -1
Users' Consumer Surplus Concept



HSGT fares in this study are set to maximize net revenue in competition with other modes,[4] not to exact from travelers the full value of each trip to them.[5] The **users' consumer surplus,** then, is the difference between the amount an individual would be willing to pay for HSGT service and the amount demanded of her or him by the HSGT entity. For example, a traveler might be willing to pay $25 for using HSGT to go from City A to City B, but the HSGT operator charges only $20 because that fare yields the maximum net revenue. The $5 difference is what economists traditionally call "consumer surplus."[6,7]

For this study, the users' consumer surplus estimation procedure adopted the steps demonstrated in Figure Chapter 6 -1. Because the travel demand model is highly sensitive to fare levels (note downward slope of the diagonal line relating fares to ridership), increasing the fare from the base fare "A" to "D" and rerunning the model results in lower ridership ("E"). The lower number of projected HSGT users represents the number of people who would be willing to pay the extra fare for the HSGT benefits, and the added fare times the number of travelers willing to pay it represents the first increment of users'

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[4] See Chapter 4 for this fundamental assumption.

[5] Exacting the full value at the farebox is, indeed, the purpose of yield management as practiced by Amtrak and the airlines today. However, state-of-the-art demand projection techniques cannot yet deal with the multiplicity of ever-changing fares characteristic of yield management. To the extent that an HSGT entity would be able to manipulate its fares to exact the full value of travel from each passenger, revenues and operating surpluses would increase and consumer surpluses would decrease from the levels projected herein.

[6] In economic terms, to the extent that the publicly-borne costs exceed the benefits to the public at large in a given case, the consumer surplus may be regarded as a subsidy enjoyed by the users.

[7] See Robley Winfrey, *Economic Analysis for Highways*, 1969, and American Association of State Highway and Transportation Officials, *A Manual on User Benefit Analysis of Highway and Bus-Transit Improvements*, 1977. OMB Circular A-94 also addresses consumer surplus in the context of cost/benefit analysis.

consumer surplus with respect to fare level “A.” Increasing the fare again to “G” will result in even lower ridership (“H”). The new ridership times the fare increase from level “D” represents the next increment in users’ consumer surplus. At some maximum point, the fare level is sufficiently high to discourage almost all riders and no additional increment of users’ consumer surplus can be found. For purposes of this study, a maximum of three times the base HSGT fare (“G” in the schematic) is used as the upper limit. By running the ridership model and increasing fares from the base level “A” to the upper limit, then summing up the increments in users’ consumer surplus at each fare level, the users’ consumer surplus can be calculated for each corridor and technology option.

BENEFITS TO THE PUBLIC AT LARGE

For purposes of this analysis, benefits to the public at large consist of three items—savings from congestion delay at airports and on highways, and emissions savings.

Airport Congestion Delay Savings

As explained in Chapter 2, congestion and delays experienced by aircraft and passengers alike are reaching high levels, especially in California, the Chicago region, and the Northeast Corridor. By diverting passengers from the air mode, HSGT would help to reduce the rate of growth in airport congestion. Such savings would yield two sets of benefits:

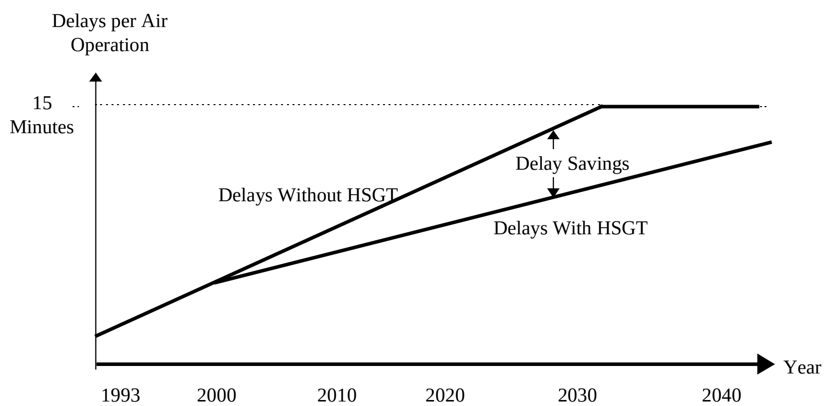
(1) **The change in operating costs, or the incremental savings, to remaining aircraft** when total takeoffs and landings are reduced and airport congestion delay decreased. Various capacity studies at highly congested airports have found significant savings are possible by reducing the hours of delay caused by the capacity-straining growth in operations (takeoffs and landings). For example, the *Los Angeles International Airport Capacity Enhancement Plan,* September 1991, concluded that, in the year 2000, when total annual operations are projected to exceed 711,000, the delay at Los Angeles International due to each additional operation (plane landing or taking off) would be 1.51 hours and add $3,360 to the operating costs of affected carriers.

(2) **The value to remaining air passengers of the travel time saved.** In addition to increasing airlines' operating costs, congestion-related delays increase the overall travel time of passengers. These delays may consist of deviations from scheduled flight departure and arrival times and added time on the taxiway or en route. Most available information pertains to wait time delays at an originating or terminating airport.

Since each airport serves a multiplicity of city-pair markets, most of which will not have HSGT service, the importance of HSGT’s effects on delay would vary with the relative prominence of HSGT markets in the airport's traffic base, and the airport's ambient traffic, capacity, and delay conditions.

Figure Chapter 6 -2 illustrates the conceptual basis for developing the airport congestion delay savings. For each major airport in a corridor, the study projected traffic growth, assumed a modicum of capacity additions, and developed average delay estimates per aircraft operation, all in the **absence** of HSGT.[8] Average delays were capped at 15 minutes per operation because such crisis-level delays would likely be viewed as intolerable.

Figure Chapter 6 -2: Concept for Airport Congestion Delay Savings



In the Year 2000, HSGT would begin to divert air traffic and palliate the rate of growth in average airport delays. The "delay savings" pictured in Figure Chapter 6 -2 would be the difference between the delays without and with HSGT. Thus, over the planning period, the airport congestion delay savings represent the sum of—

- The projected reduction of aircraft-hours of delay, multiplied by the average cost to the airlines of each delay-hour; and
- The projected reduction in passenger-hours of delay for the remaining air travelers, multiplied by the average value of air passenger wait times ($39.03/hour) included in the ridership model for this study. [9]

Highway Congestion Delay Savings

Conceptually similar to airport delay savings, the value of reduced congestion and delay on highways from diversion of auto travelers to HSGT would constitute a potential benefit of HSGT. The benefit was estimated in terms of the value to remaining highway users of travel time saved when traffic volumes on major highways in HSGT city-pair markets decrease (or grow at a

[8] These were the same general assumptions as affected the demand estimates; see Chapter 4.
[9] Charles River Associates, *Market Share Models for Forecasting Ridership on New High-Speed Intercity Transportation*, 1994.

reduced rate) and travel speeds improve. As in the case of airports, the importance of HSGT's effects on highway delay would vary with the relative prominence of intercity travel in the road's traffic mix; the share of HSGT markets in that intercity travel; and the highway's ambient traffic, capacity, and delay conditions.

Traffic removed from highways was based upon ridership model forecasts of diverted auto passengers, converted to vehicles using a vehicle occupancy of 1.2. Highway conditions and the effects of HSGT trip diversion were approximated by extrapolating from the traffic impacts at selected corridor locations including:

- Each major metropolitan area HSGT terminus,
- Each intermediate major metropolitan area, and
- One intermediate rural/low density area between major metropolitan areas.

The decrease in traffic was assumed to have a measurable effect on auto travel speeds only when facilities are significantly congested (i.e., operating at less than free flow speeds). For rural areas, a level of service of "C" or worse, and in urban areas, a roadway congestion index of 1.0 or higher, were established as thresholds for significant congestion .[10] Using relationships of the volume-to-capacity for a roadway and associated travel speeds, the decrease in traffic due to HSGT diversions was converted into a change in highway speeds. The change in speed was converted to travel time savings for remaining auto users, whose in-vehicle travel time was valued at $10.88 per hour.[11,12]

Emissions Savings

The diversion of travelers from auto and air transportation modes to HSGT will create the potential for emissions savings. Regarding emissions, the differences among modes relate to the nature of their respective fuel sources and to the specific power (i.e., per seat-mile and, by extension, per passenger-mile) necessary to overcome inertia and to counteract three classes of force:

- Air resistance (all modes);

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[10] *Highway Capacity Manual*, Special Report 209, Transportation Research Board, 1985 (revised), and *Trends in Urban Roadway Congestion - 1982 to 1991*, Volume 1: Annual Report, Texas Transportation Institute, 1994.

[11] This value of time is derived from studies undertaken by the Texas Transportation Institute for the National Cooperative Highway Research Program, Transportation Research Board, and National Research Council. *Benefit-Cost Evaluation of Highway Improvements, MicroBENCOST Program*, Version 1.0, Texas Transportation Institute, 1993.

[12] Just as this methodology projects congestion reduction benefits for HSGT in the realm of intercity transportation, so has the Federal Transit Administration (FTA) found that metropolitan public transit reduces annual losses from traffic congestion by about $15 billion annually. (FTA, *National Transit Report—1996,* p. 4.) Recent research for FTA by the firm of Hickling-Lewis-Brod indicates that transit markedly improves the point-to-point speed of travel for both transit riders and highway users in severely congested urban travel corridors.

- Gravity (air and Maglev); and
- Contact/rolling resistance (wheeled modes).

A method was developed to calculate emissions savings based on changes in energy use with and without HSGT. The method accounted for the region of the country, the status of compliance with air quality regulations of counties through which each route passes, and the projection year. Access and egress modes were considered in addition to the line-haul portions of trips. Emission factors from the EPA and manufacturers were compiled for representative air, rail, and auto vehicles over the study period from 2000 to 2040. Based on assumptions about intercity trip characteristics and ridership forecasts, emissions were projected with and without HSGT options in place; the savings ascribed to HSGT represent the difference between the emissions levels "with" and "without" the HSGT mode.

The valuation of emissions savings recognized the attainment status of the impacted counties for all emissions except carbon dioxide (CO_2) and sulfur oxides (SO_x). CO_2 was valued at $15 per ton based on CO_2's impact on the global green-house effect, while SO_x was valued at $600 per ton based on estimates for the value of emission allowances traded on the commodities market. For other emissions, the value reflected control costs in non-attainment counties, with no value assigned for emissions within attainment counties. As a result, the values associated with emissions savings ranged from zero in attainment areas to a peak in Los Angeles of $18,900 per ton of reactive organic gases (ROG), $9,300 per ton of carbon monoxide (CO), $26,400 per ton of nitrous oxides (NO_x), and $5,700 per ton of particulate matter (PM_{10}).[13,14]

OTHER IMPACTS: BACKGROUND INFORMATION

This section provides information on the items that did not qualify, in this study, for inclusion in total benefits.

Transportation Items

The following impacts directly affect transportation system efficiency, costs, and safety.

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[13] Argonne National Laboratory, *Methods of Valuing Air Pollution and Estimated Monetary Values of Air Pollutants in Various U.S. Regions*, U.S. Department of Energy, 1994.

[14] Close linkage of HSGT with existing public transit systems in dense urban areas might enhance the emissions benefits cited in this section. FTA has found that existing levels of transit use annually avoid about 125 million pounds of hydrocarbons and over 150 million pounds of nitrous oxides that would otherwise be emitted by automobiles. (FTA, loc. cit.)

Airport Investment Deferrals

Many commercial airports in proposed HSGT corridors face pressures to expand significantly to accommodate future travel demand.[15] HSGT could divert some traffic from air, thereby mitigating the need for capacity-related improvements at increasingly congested commercial airports. This study could not include these reduced or deferred capital expenditures in total benefits, since they measure the same phenomena as the airport congestion delay savings.

Highway Infrastructure Savings

The diversion of automobile traffic to HSGT would mitigate or defer the need for highway expansion, measured in terms of lane-miles that would otherwise be dedicated to carrying the diverted trips. The costs saved or deferred by not having to expand roadways could not be included in total benefits, since they measure the same phenomenon as the highway congestion delay savings.

Commuter Rail Travel Efficiency Benefits

By enhancing the railroad passenger infrastructure in major metropolitan areas, HSGT could theoretically lead to faster commuter schedules, with time savings for existing riders. The better timings would also attract new riders, thus favorably impacting highway congestion.

In the course of developing the capital program for the HSGT cases, this study calculated the potential trip time savings on appropriate commuter routes. To quantify and monetize the likely future benefits, however, would require detailed site-specific studies because—

- Commuter trains, with their frequent stops, cannot always take full advantage of improved line-haul speeds[16]; and
- While producing secondary benefits in terms of highway congestion relief, the additional commuter patronage could entail significant capital costs and increased operating deficits.

Transportation Safety Improvements

To the extent that HSGT options in the United States actually establish sustained safety records better than those of existing modes,[17] trip diversions to HSGT might ultimately reduce

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[15] Cf. Figure 2-3.

[16] Between Baltimore and Washington, for example, the schedules for multi-stop commuter trains in 1995 were not much better than before the Northeast Corridor Improvement Project, although express schedules had shortened. In such cases the benefits will depend on how many people use what types of trains—a fitting subject for intensive local study.

[17] The Federal Railroad Administration's Next Generation High-Speed Rail Program and related research and development efforts aim toward making the HSGT options at least as safe as their European counterparts.

the number of accidents and their attendant fatalities, injuries, property damage, and costs in both human and monetary terms. Because significant methodological and data issues[18] stand in the way of a straightforward, broadly acceptable projection of the safety benefits of HSGT, this study did not include, in total benefits, savings from that source.

Economic Development Items

Since economic development impacts would ordinarily represent transfer effects (as explained on page 6-3), they do not enter into "total benefits" in this report. However, the following impacts could be of some interest at the State and local level:

Multiplier Effects—HSGT Construction and Operations

For one industry to function, its production process requires, as inputs, the goods or services produced (output) by other industries. In addition, wages circulate in the economy as part of household purchases. In this manner, each dollar of spending for transportation stimulates additional spending, affecting other industries in the economy; this is known as a "multiplier" effect. Therefore, expenditures to build and maintain infrastructure and operate transportation services, such as HSGT, could influence a local or regional economy.

Station Development Effects

Development investment, including office, retail, hotel, and some housing, may gravitate to the vicinity of HSGT stations from less attractive locations in the corridor because of HSGT-induced changes in spatial/temporal relationships, as well as the market potential represented by HSGT riders.

Growth of an American HSGT Supply Industry

Most rail passenger car manufacturers are now located outside the United States, although there are local suppliers and assembly facilities to comply with the normal requirement of 50 percent United States content for Federally-funded acquisitions. To the extent that HSGT ultimately expands in the United States to become a consistent and predictable market for transportation equipment, the private sector may be willing to consider long-term investments that would increase the American involvement in HSGT vehicle design and manufacture.

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[18] Such a method would be based on projected passenger diversions among modes. Examples of the issues include: whether to address nonpassenger as well as passenger fatalities; whether to include access/egress fatalities as well as line-haul fatalities; how to treat Maglev, for which no revenue safety experience exists; and what base to use for HSGT fatality rates, since Amtrak's existing annual results— skewed by relatively low passenger-miles in the denominator and marked year-to-year variations in fatalities in the numerator—do not represent the expected performance of the HSGT options, while the safety rates for the various high-speed services overseas may not necessarily apply equally to all American HSGT technologies.

Environmental/Energy Items

Environmental

With the prominent exception of emissions savings (discussed on page 6-8), the proper estimation of most environmental costs and benefits of HSGT options requires detailed, site-specific data and community participation that can only issue from a State-sponsored or regional corridor study. These environmental factors include but are not limited to:

Noise. Noise effects relate directly to the percentages of highway and air passengers diverted to rail, the percentage increase in rail volumes, and the relative exposure of residences to the relevant highways, airports, and railroads.

Water quality. Passenger diversions from highway and air to rail affect both the volumes of polluting traffic and the likely expansion of impervious surfaces for highway and airports. Because railroad ballast filters runoff very well, and because railroads make minimal use of impervious surface, rail passenger facility and service expansions have insignificant direct effects on water quality in comparison with the other transportation modes.

Land consumption. Because land consumption is directly determined by the expansion of transportation facilities, the factors to be considered include percentages of highway and air passengers diverted to rail, the relative degree of congestion on other modes' facilities, and the planned increase in rail right-of-way.[19]

Community disruption. Factors affecting the analysis of community disruption effects include the change in train frequency, the degree of grade separation of rail and highway traffic planned for each technology, the number and location (urban/rural) of grade crossings before improvement, and the total change in delay at grade crossings, including that delay avoided by elimination of grade crossings.

Endangered species habitat; wetlands. These two environmental areas are very similar in treatment; the related impacts are determined by land consumption, incidence and quality of habitat and wetlands, and type of expanding mode.

Energy

Energy savings may result from the diversion of travelers from auto and air transportation modes (propelled by on-board fossil fuels) to HSGT (propelled either by on-board fossil fuels or by a mix of energy sources).

[19] Close integration of HSGT stations with existing transit systems, particularly in the urban core, could enhance HSGT's potential public benefits as they relate to community planning and development issues.

Although quantifiable and monetizable,[20] the dollar value of energy savings could not enter into total benefits because fuel and power costs already directly affect the operating expenses of the HSGT options, the perceived cost of auto travel, and the economics of the airline industry. It would be double counting to include, within total benefits, the dollar value of reduced use of this ubiquitous material of transport production. Beyond the value of the energy savings per se, lower petroleum consumption due to HSGT might help to wean the Nation from its dependence on foreign oil sources. To translate the intangible concept of "energy independence" into straightforward monetary values would, however, entail international trade and other major policy issues that exceed the scope of this report.

[20] Indeed, in the course of this study and in conjunction with the projections of emissions savings, a methodology was developed to calculate differential energy usage with and without implementation of HSGT. The methodology accounted for the region of the country, the mix of fuels for electricity generation in each, and the projection year. Access and egress modes were considered in addition to the line-haul portions of trips. Energy consumption factors from manufacturers were compiled for representative air, rail, and auto vehicles for the 2000 to 2040 study period; for the HSGT options, the vehicle performance assumptions were those of Chapter 4. Based on demand model outputs for intercity trip characteristics and ridership forecasts, energy savings due to HSGT were projected.

CHAPTER 7
RESULTS

This chapter synthesizes, by topic, the results of the projections.[1] It covers not only system requirements and performance but also benefits and costs, and treats all the illustrative corridors except for the Empire and Southeast examples, which the analysis regarded as Northeast Corridor extensions and which receive special treatment in Chapter 8.

SYSTEM REQUIREMENTS AND PERFORMANCE

Investment Requirements

Initial investment costs for HSGT vary widely among corridors, and particularly among technological options. The more ambitious options show the widest variations among corridors in absolute terms, as Table Chapter 7 –1 shows.[3]

The variations within each technology reflect several important factors:

Table Chapter 7 –1
Initial Investment Cost Ranges
for Illustrative Corridors

Technology	Typical Range of Total[2] Initial Investment per Route-Mile (Millions of Dollars)
Accelerail 90	$1 to $3.5
Accelerail 110	$2 to $5
Accelerail 125F	$3 to $5.5
Accelerail 125E	$5 to $7.5
Accelerail 150F	$4.5 to $7
Accelerail 150E	$6.5 to $9
New HSR	$10 to $45
Maglev	$20 to $50

Corridor length. Because each individual corridor was estimated as a separate project, shorter corridors must absorb a greater share per route-mile of fixed support facilities (e.g., equipment shops) than longer corridors. San Diego—Los Angeles has relatively high costs for this among other reasons.

Traffic densities. As traffic densities increase (including ambient freight and commuter volumes in Accelerail options), the need arises for more double track and passing sidings.

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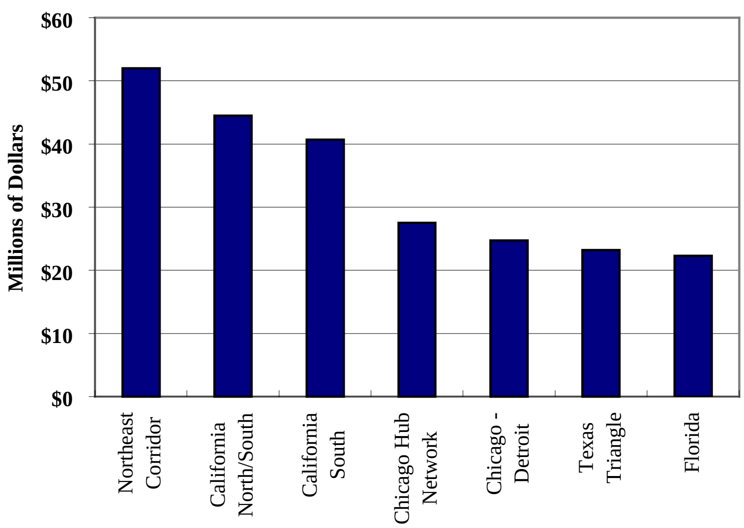
[1] By their very nature, projections depend on the reasonableness of their underlying assumptions (described in Chapter 4) and are subject to divergences between the assumptions and actual conditions. For these and other reasons, the results of the systems described in this report may vary materially from the projections. This further underscores the need for detailed studies prior to initiation of corridor development.
[2] I.e., including infrastructure and vehicles.
[3] See Table Chapter 7 –4, page 7-22, for the projected initial investment by case.

Size of vehicle purchase. The initial vehicle purchase varies with route mileage, HSGT ridership, and concomitant frequency. While amounting to between 20 and 40 percent of the initial cost of Accelerail 90 and 110 cases, vehicles comprise a small portion of total costs for more intensive options. The importance of vehicles in the initial costs of Accelerail 90 and 110 may enhance the commercial feasibility of those options, since vehicles are a more fungible investment than fixed facilities and have traditionally attracted lease financing.

Figure Chapter 7 -1
Initial Investment per Route-Mile: Maglev Examples



Setting. Corridors that entail difficult mountain crossings, require major tunneling, or traverse continuously urbanized landscapes naturally incur relatively high initial costs.

Figure Chapter 7 -1 summarizes the effects of these factors on the Northeast Corridor and California, as compared with some other potential HSGT sites.[4]

Whatever the cost, the different investment levels share a single purpose: to reduce line-haul travel times, and—by extension—total travel times.[5] Yet the various technology options do not produce even gradations in their trip-time effects. In fact, the typical pattern, shown in Figure Chapter 7 -2 for Chicago—St. Louis, involves—

- A sharp decrease in existing Amtrak running times with the institution of tilt-train Accelerail 90 service;

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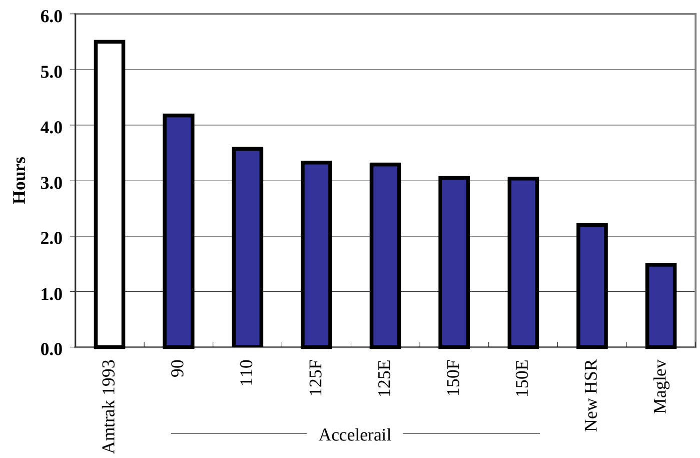
[4] California's initial investment costs call for a brief explanation in light of the complex alignment situation caused by the topography and demographics of that State. In order to provide a broad range of initial costs in the Los Angeles—Bay Area segment of the corridor, this study assumed the lowest possible cost solutions at the Accelerail 90 and 110 level: via the existing Coast Line. Employing the somewhat more heavily populated Valley route via Fresno and Stockton to Oakland, the Accelerail 125 and 150 options assumed a new right-of-way only between Los Angeles and Bakersfield across the Tehachapi Mountains. Finally, the New HSR and Maglev cases were likewise assumed to cross the Tehachapis but to follow a new, more westerly alignment from the Fresno vicinity to San Jose and downtown San Francisco. Due to the massive civil works assumed in Accelerail 125 and above, the non-coastal California cases have a much higher cost per route-mile than the ranges shown in Table Chapter 7 –1.

[5] See below under "demand and revenues" for a discussion of total travel times.

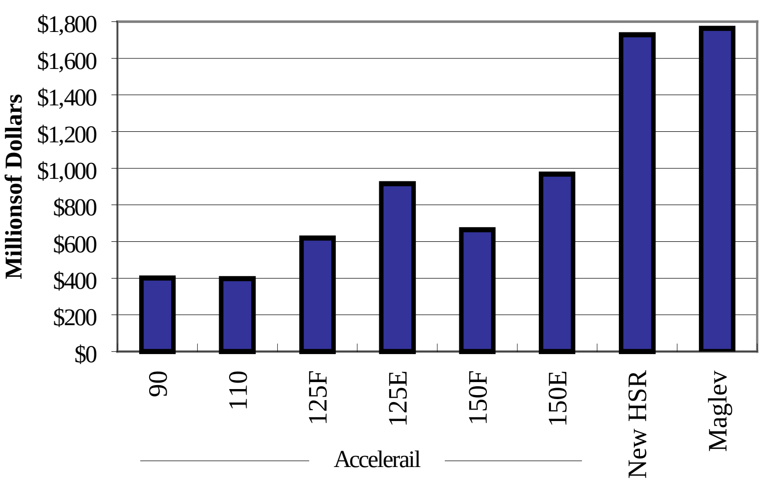
- A still marked trip time improvement in Accelerail 110;
- Slight improvements in the 125 and 150 Accelerail range; and
- Dramatic trip time benefits from New HSR and, especially, Maglev.

Figure Chapter 7 -2
Line-Haul Running Times, Chicago—St. Louis



Investment requirements grow, sometimes dispro-portionately to trip time savings, as the options become more ambitious. These trends lead to the pattern typified by Figure Chapter 7 -3, showing the dollars of initial investment per timetable-hour saved over Amtrak's 1993 performance in the Chicago—Detroit corridor. The cost per hour saved grows noticeably, although not steadily, beyond the Accelerail 110 case. This escalating cost of travel time savings raises the question whether demand and revenues grow commensurately across the options.

Figure Chapter 7 -3
Initial Investment Per Hour Saved Over Amtrak 1993 Base
Example: Chicago—Detroit



Demand and Revenues

In response to an ever-improving product across the range of options, the cases generate significant demand and revenues, in several cases surpassing the 1.3 billion passenger-miles generated by Amtrak in the Northeast Corridor in 1993.

The Product

The HSGT product has three salient characteristics, which work together to influence ridership in the models for this study: travel times, fares, and frequencies.[6]

Travel Times

The ability to divert patrons from existing modes depends not on line-haul times but on comparative total travel times, which also include access to, egress from, and time spent in stations. The composition of those total travel times varies dramatically among modes, as shown in Figure Chapter 7 -4 for the Chicago—Detroit market. In any comparison of total timings, auto has an inherent advantage in its door-to-door convenience (avoiding access and terminal time), and air benefits from its superior cruising speeds.

Figure Chapter 7 -4
Composition of Each Mode's Total Travel Time
Example: Chicago—Detroit City Pair

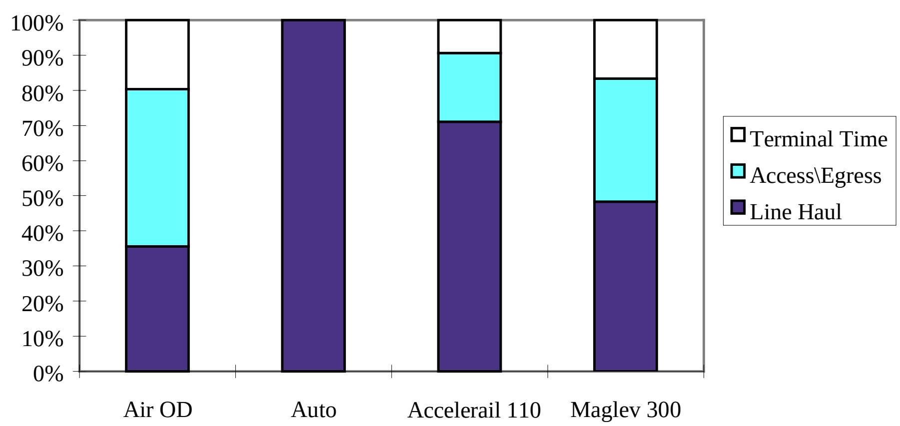
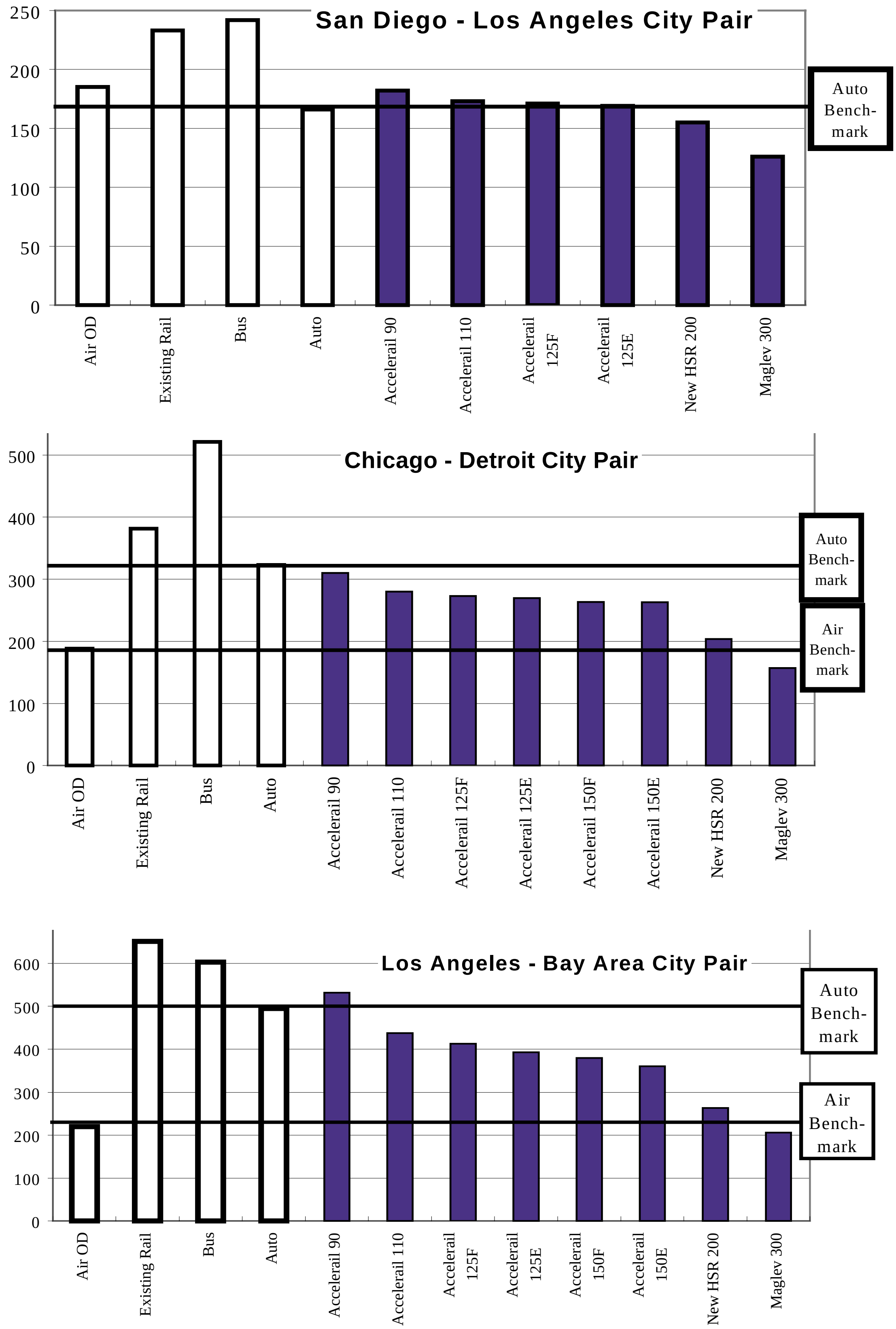


Figure Chapter 7 -5 compares the total travel times by mode in three sample city-pairs: San Diego—Los Angeles (128 miles), Chicago—Detroit (280 miles), and Los Angeles—Bay Area (425 miles). The examples indicate that an Accelerail trip, in total, can take longer than the often cheaper auto in shorter city pair markets, but that Accelerail timings can better those of auto in medium- and longer-distance corridors.   Maglev can outperform air on total travel times even in markets in the 400-mile range, whereas New HSR approaches but does not achieve time comparability with air in such longer markets. The competitive situation will, of course, differ from market to market depending on specific route length and

[6] Service quality factors are theoretically represented in the coefficients of the demand models. Obviously, a transport entity that finds new ways to serve the public better can defy the limitations of mathematical models and do better than the predictions, just as a failure to provide quality control after the project is built will undermine operating and revenue performance.

Figure Chapter 7 -5: Competitive Position of HSGT in Three Sample City Pairs—Total Travel Time in Minutes

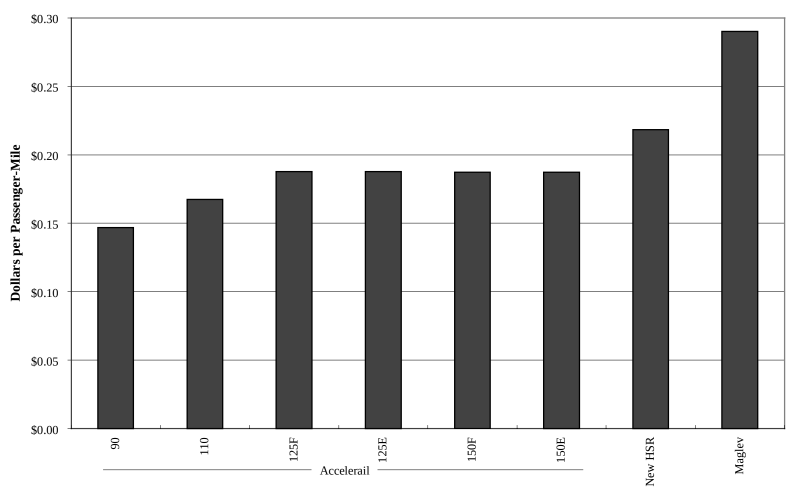


alignment considerations and traffic congestion levels in major cities. The demand projections for this study clearly reflect these competitive facts of life: the diversion rates to HSGT from auto and air mirror very closely the decreases in HSGT trip times across options.

Fares

Average fares, as measured by yield,[7] vary dramatically from one corridor and option to another, in response to the competitive situation and to the quality of the HSGT product. Generally, fares increase gradually as travel times improve across the options, since the traffic will bear a higher price for an improved service. In keeping with the trip time trends described above, the increases are particularly marked in the range of Accelerail 90 and 110, and again for New HSR and Maglev. The Chicago Hub Network's fares, depicted in Figure Chapter 7 -6, typify the trends in the illustrative corridors.

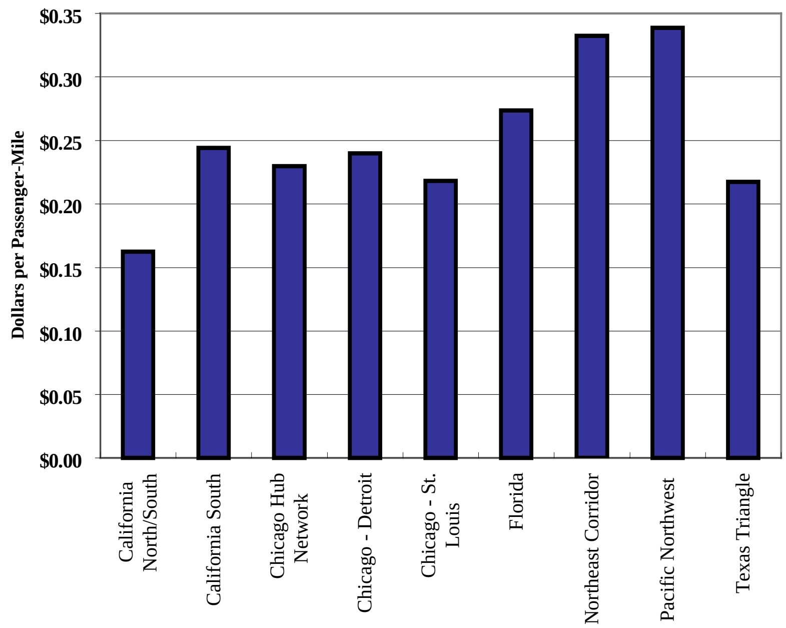
Figure Chapter 7 -6
Fare Yields in the Chicago Hub Network (Year 2020)



Across all options, each corridor has a distinct niche on the array of fare levels, as shown in Figure Chapter 7 -7. What the traffic will bear in one corridor, in the presence of low-fare air competition, will differ markedly from yields in corridors where airline operating costs and prices are high. The California corridor illustrates this point: low-fare airline competition over the prime Los Angeles—Bay Area market precludes the HSGT operator from charging high fares. The only significant increase in fares over 16 cents per mile—in Maglev, which betters total air travel time between Los Angeles and the Bay Area—remains

[7] The models for this study posit specific business and nonbusiness fares for each HSGT city-pair. The average fare yield per passenger-mile in each corridor (passenger transportation revenues divided by passenger-miles) indicates the relative prices charged to HSGT passengers and provides the basis for this section.

Figure Chapter 7 -7
Fare Yield by Corridor, Year 2020
Example: New HSR



at 20 percent, because Maglev's travel-time edge is not pronounced. By contrast, the Northeast Corridor—with its high air fares and ideally-configured HSGT markets (particularly New York to Washington, and New York to Boston)—allows for very high New HSR and Maglev yields, more than half again as high as the current Amtrak estimated average fares.

Frequencies

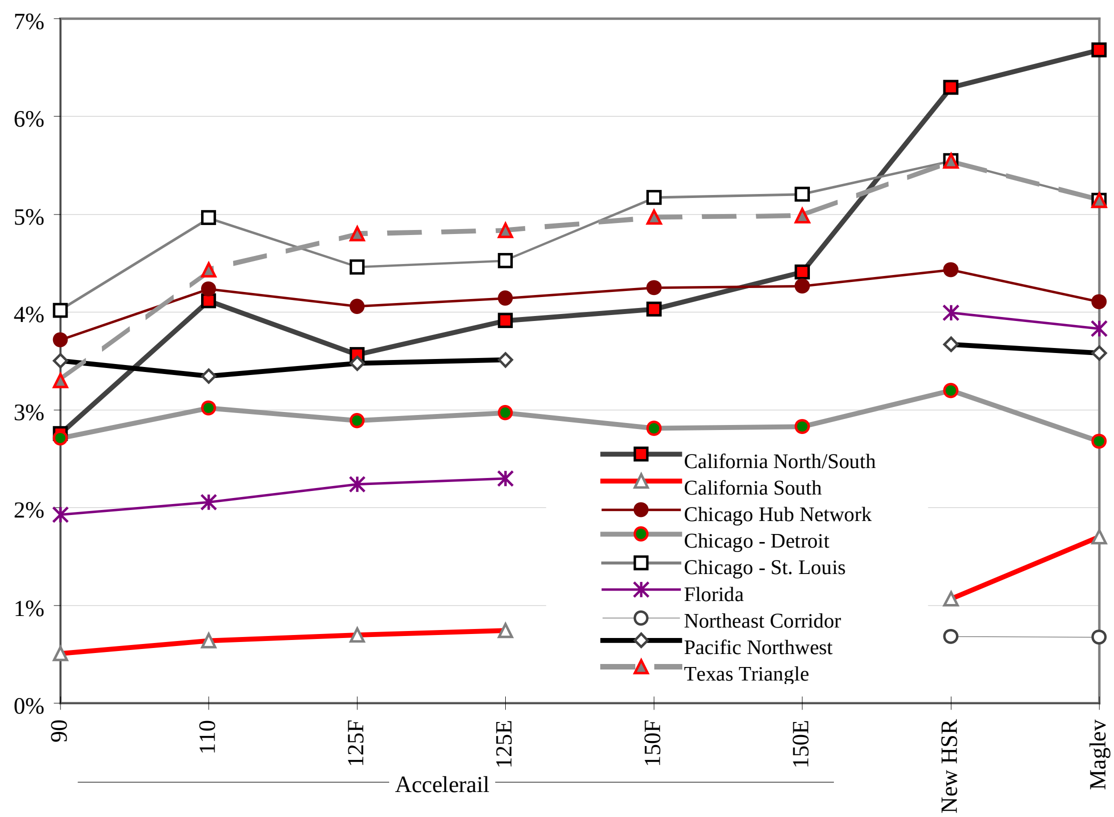
Frequencies—arrived at iteratively—vary significantly among corridors and cases in response to, and as a contributing factor toward, demand. For the Accelerail options, most corridors support between 10 and 20 round trip trains per day. The California corridors, with their heavier traffic densities, justify more frequent service. New HSR and Maglev both entail much higher train frequencies, as exemplified by the 100 daily round trips projected in the Northeast Corridor between New York and Washington. These high frequencies allow New HSR and Maglev to attract ridership despite their generally higher fare levels.

The Outcome

This analysis suggests some limitations on the ability of HSGT to divert auto traffic under current travel and land use patterns, conditions of energy availability and price, nearly universal auto ownership, and the ready availability of the Interstate System. **Should these**

underpinnings of America's transportation structure shift in a fundamental way—beyond the mere inconvenience of growing congestion, which affects all modes—diversion levels from auto to HSGT would be higher. As projected in this study, however, most cases divert between three and six percent of auto trips (Figure Chapter 7 -8). The travel time improvements in New HSR generally attract noticeably higher auto diversions, despite fare increases of 20 to 40 percent over Accelerail levels. In California, where air competition obviates such fare increases, the auto diversion rate grows by 50 percent from Accelerail to New HSR.[8]

Figure Chapter 7 -8
Percent of Intercity Auto Traffic Diverted to HSGT by Corridor, Year 2020



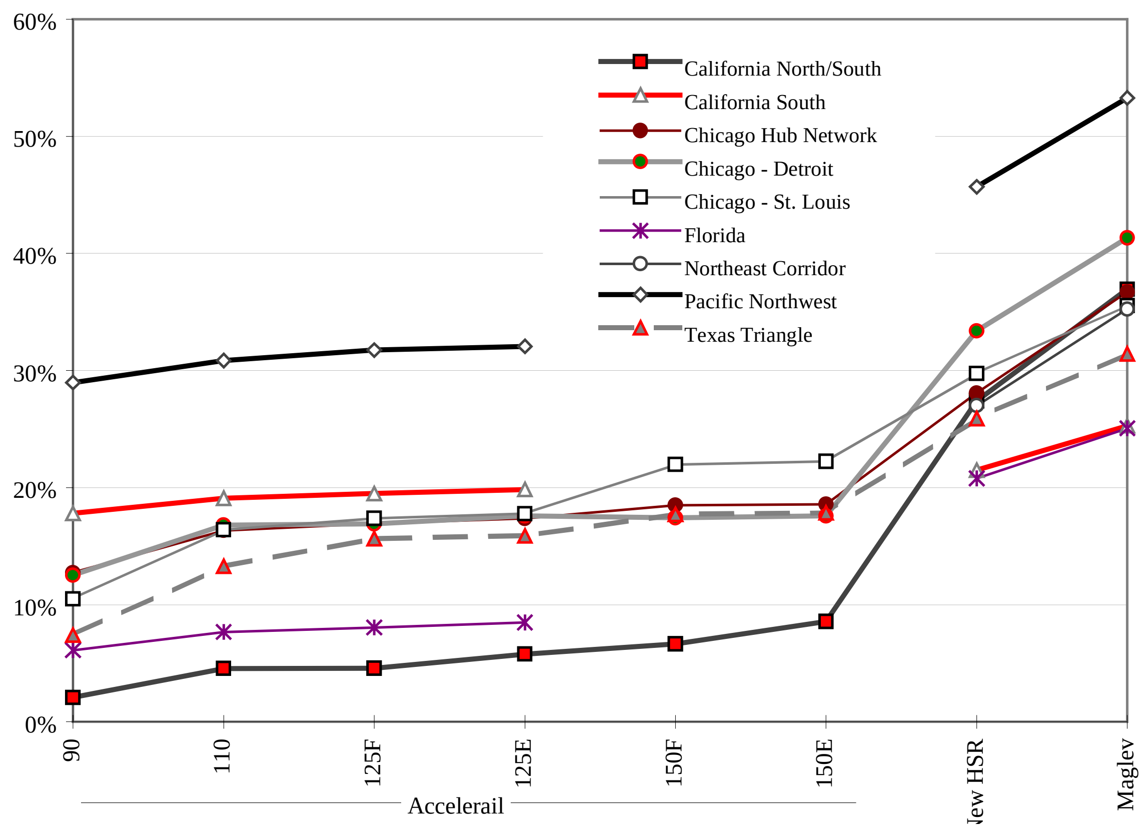
Corridors with short average trip lengths (under 150 miles) show the lowest diversion rates, for price and time reasons described above. Auto diversion percentages for New HSR and Maglev in the Northeast Corridor are relatively low because they are incremental to those accomplished by Accelerail 150E, assumed to be in place by 2000, and by its precursor Accelerail 125E, currently extant.

[8] Of course, the trip time improvement from Accelerail to New HSR is particularly strong in California due to the routing changes explained in footnote 4.

The auto diversion rates to Maglev show in stark relief the balancing act inherent in HSGT pricing. With total trip times often better than for any other mode, Maglev can support very high fares in airline-competitive markets. This policy will often maximize net revenues to the HSGT entity, but discourage auto diversions. An actual Maglev operator would have the flexibility to use yield management and variable pricing to maximize revenue and still attract greater automobile-based traffic levels than those posited here.[9]

While varying widely due to local market conditions, air diversion percentages

Figure Chapter 7 -9
Percent of Intercity Air Traffic Diverted to HSGT by Corridor, Year 2020



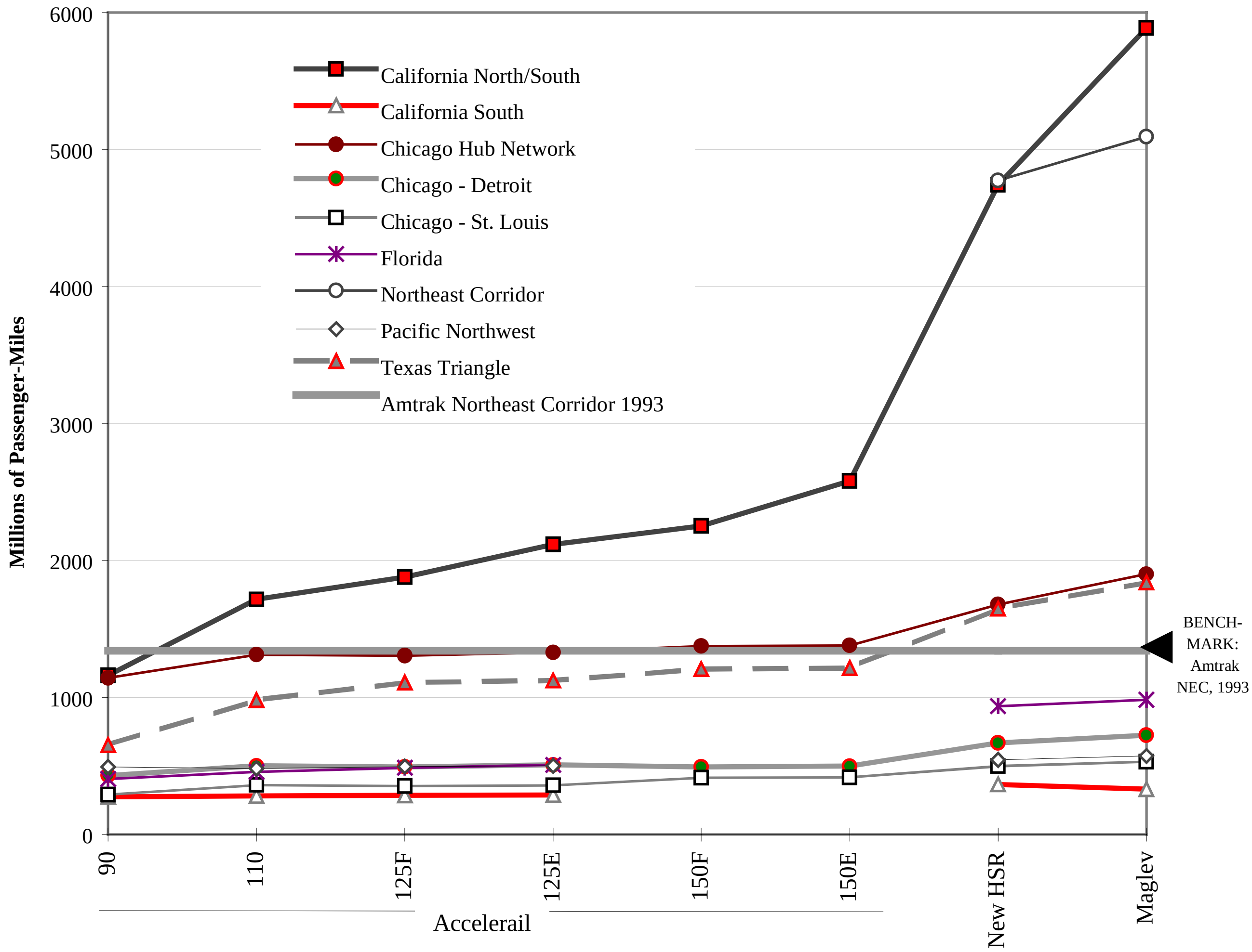
respond generally to the degree of improvement in the HSGT product and, with New HSR and Maglev, from one fifth to half the air traffic base diverts to HSGT. (See Figure Chapter 7 -9.) Whatever the starting point, the diversions climb markedly to Accelerail 110, grow by degrees through the other Accelerail options, and soar with New HSR and Maglev as HSGT enters the range of time parity with air in major endpoint markets. The curve is steepest where the improvements are proportionately greatest—in the long California corridor, with

[9] The greatest challenge HSGT faces in attracting automobile traffic is overcoming the inherent economic advantage enjoyed by the automobile for two or more persons traveling together. Since the auto can carry several people for the same cost as carrying one, its price advantage compared to public transportation increases with group size.

the introduction of a new alignment between Los Angeles, the Central Valley, San Jose, and downtown San Francisco in the New HSR and Maglev options. The Northeast Corridor air diversion rates in Figure Chapter 7 -9 are all the more noteworthy because they are incremental to such diversions as have already taken place or are ascribed to Accelerail 150E.

These air and auto diversions, plus diversions from rail and bus where applicable, combine to produce large quantities of transportation in many of the illustrative corridors. Figure Chapter 7 -10 summarizes the passenger-miles by case in the year 2020 and provides a useful benchmark for size: Amtrak's 1993 operation in the Northeast Corridor, the largest rail passenger market in North America. The chart indicates that—

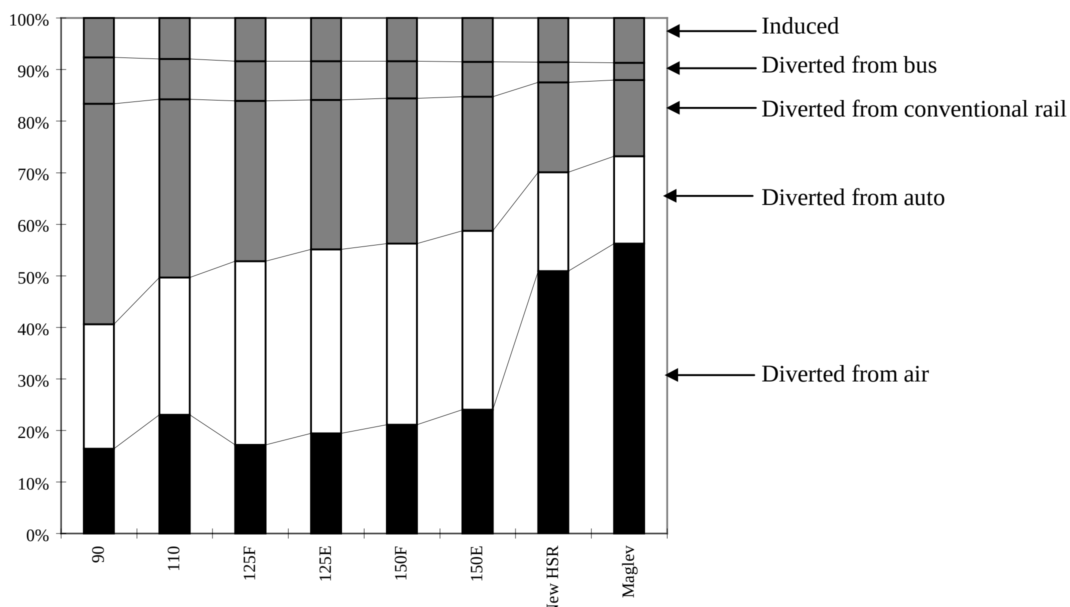
Figure Chapter 7 -10
Passenger-Miles, Year 2020, by Corridor



- Three corridors may exceed Amtrak's existing Northeast Corridor volumes by the year 2020: the California North/South corridor, the Chicago Hub Network, and the Texas Triangle. California could generate volumes four times as large as the Northeast Corridor did in 1993.
- The Northeast Corridor traffic could quadruple by the year 2020 with the introduction of New HSR or Maglev.
- Commensurate with their size, several other corridors would also generate sizable traffic levels, approaching half the benchmark Northeast Corridor volumes.

These are significant volumes, and noteworthy findings. **Despite profit-maximizing fare levels and very modest diversions, particularly from auto, HSGT would generate transportation production on a meaningful scale outside the Northeast Corridor, although at a significant financial cost.** While sheer size cannot assure partnership potential, it underlines the importance that HSGT can achieve in intercity transport on a nationwide scale.

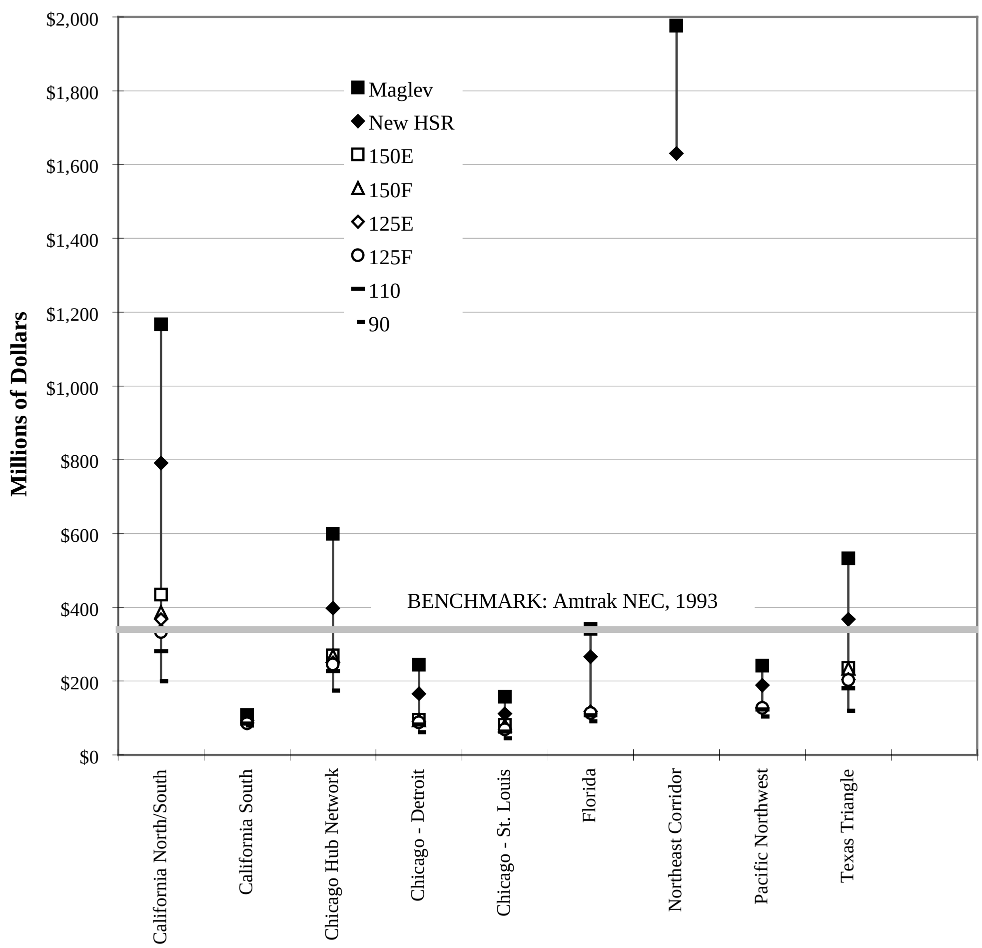
Figure Chapter 7 -11
California North/South Corridor—
Composition of Traffic Base by Option, Year 2020



The composition of the HSGT traffic base would reflect diversions from the source modes. Figure Chapter 7 -11 depicts the shifts, by option, in the sources of the traffic base in the California North/South corridor. In particular, the chart shows how diversions from air assume a predominant role in the New HSR and Maglev options, in keeping with their trip time capabilities.

The combined effects of the pricing policies and passenger volumes appear in the total system revenues, summarized in Figure Chapter 7 -12. Here too, the California North/South, Chicago Hub Network, and Texas corridors could exceed the Northeast Corridor 1993 benchmark. The huge volumes and higher fares in the Northeast Corridor for New HSR and Maglev would, of course, produce revenue levels much higher than for other corridors.

Figure Chapter 7 -12
System Revenues by Corridor and Technology Option, Year 2020

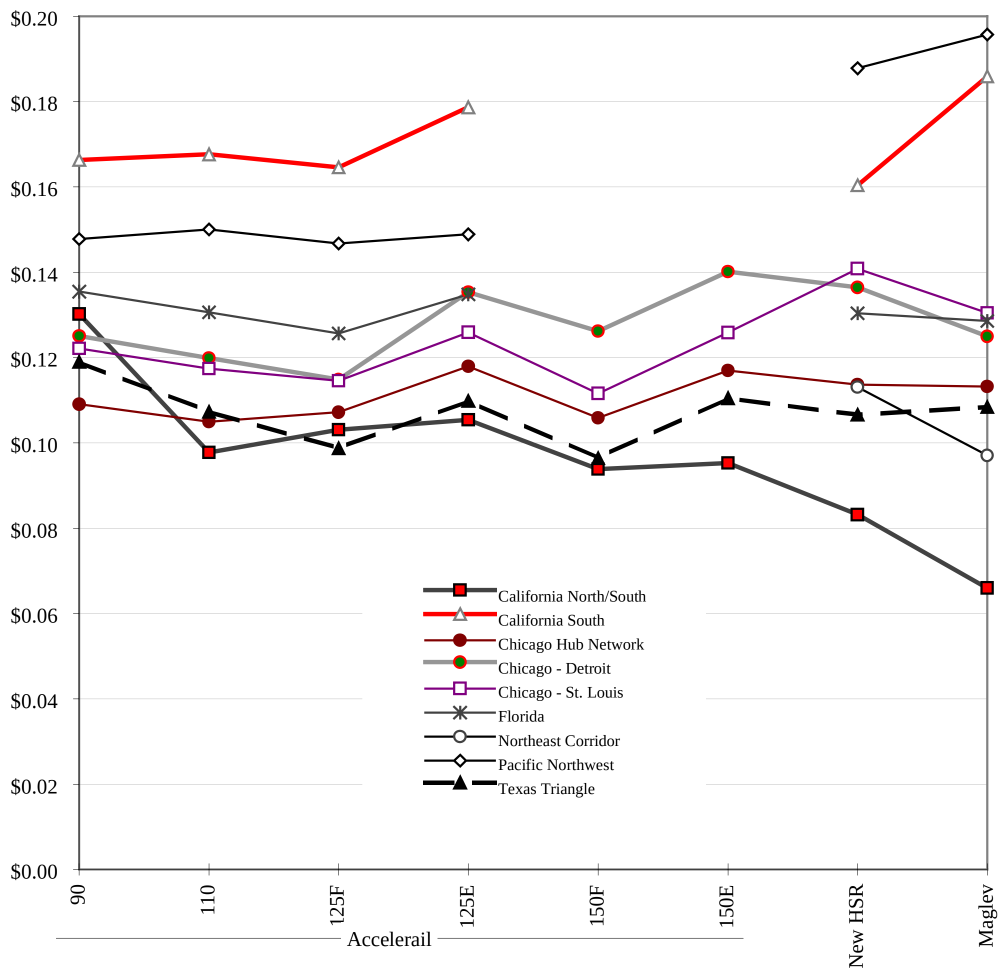


Operating and Maintenance Expenses

For most illustrative corridors, this analysis projects HSGT to cost approximately 10 to 14 cents per passenger-mile to operate and maintain. (Figure Chapter 7 -13.)

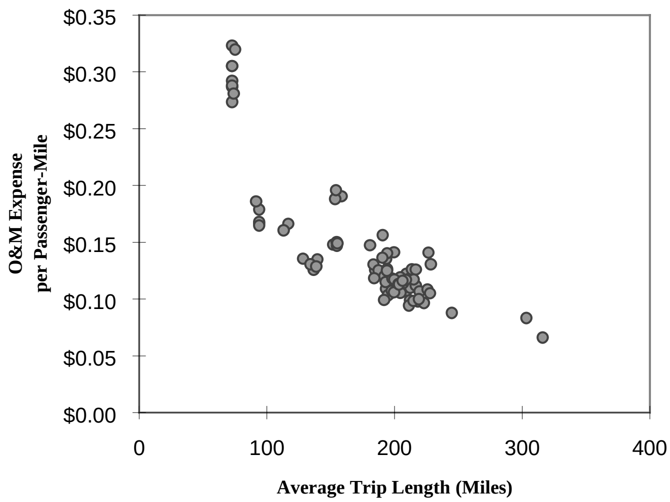
For all cases taken together, the operating and maintenance expense model produces unit expense results that respond predictably to system design and operating efficiencies. Such factors as traffic volume, route length, passenger-miles per train-mile, load factor, passenger-miles per gross ton-mile, passenger-miles per train-hour, and average trip length strongly influence the cases' expense levels. Figure Chapter 7 -14, for example, shows a discernible relationship between average trip lengths and operating and maintenance unit expenses.

Figure Chapter 7 -13
Operating and Maintenance Expenses Per Passenger-Mile, Year 2020



Differences in unit expense levels **among corridors** reflect in large measure the above factors as predestined by each region's geography and demographics. Exemplifying this phenomenon are the Maglev cases in California and the Northeast Corridor; the former,

Figure Chapter 7 -14
Operating and Maintenance Unit Expenses Versus Average Trip Lengths
(Year 2020—All Cases)

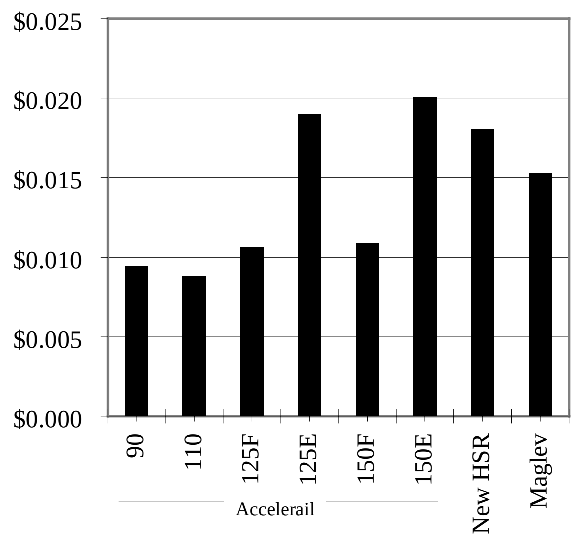


with its major city pair 400 miles in length and average trip lengths of 316 miles, can reach load factors of 56 percent, or 14 percent higher than those of the latter, with its major point of attraction in the center (New York), much shorter major markets on either side, and a 192-mile average trip. For these reasons among others, Maglev in California would enjoy unit operating expenses one-third less than those of the Northeast.

Among options in each corridor, expense levels respond to the different technologies and institutional assumptions. The unit expense curves in Figure Chapter 7 -13 summarize underlying (and sometimes countervailing) trends in the major functional expense categories, as portrayed below.

Among the Accelerail options, **maintenance-of-way expenses** (Figure Chapter 7 -15) reflect, first and foremost, the presence or absence of electrification. The Maglev and New HSR options must invariably absorb the full expense of fixed plant maintenance, but their higher passenger volumes and (in the case of Maglev) technology-based economies help to moderate, and in some cases lower, the unit expenses from Accelerail levels.

Figure Chapter 7 -15
Maintenance-of-Way Expense Per Passenger-Mile
(Chicago Hub Network Example)



Maintenance-of-equipment expenses (Figure Chapter 7 -16) include fixed expenses for service, inspection, and repair facilities, and thus benefit from volume increases across options. The electrified Accelerail options, omitting on-board power generation, further reduce these expenses. New High-Speed Rail, with its two locomotives per trainset and lower-capacity cars, occasions relatively high unit expenses;

Maglev, with its revolutionary design, eliminates much of the mechanical wear and tear of the steel-wheel systems, and is projected to have the lowest equipment maintenance unit expense.

Figure Chapter 7 -16
Maintenance-of-Equipment Expense Per Passenger-Mile (Texas Triangle Example)

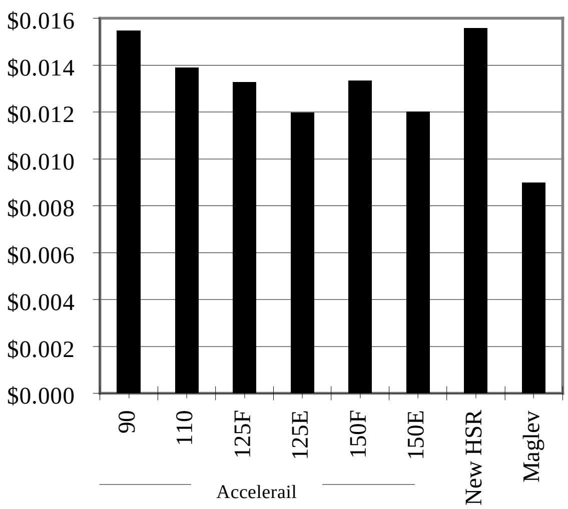
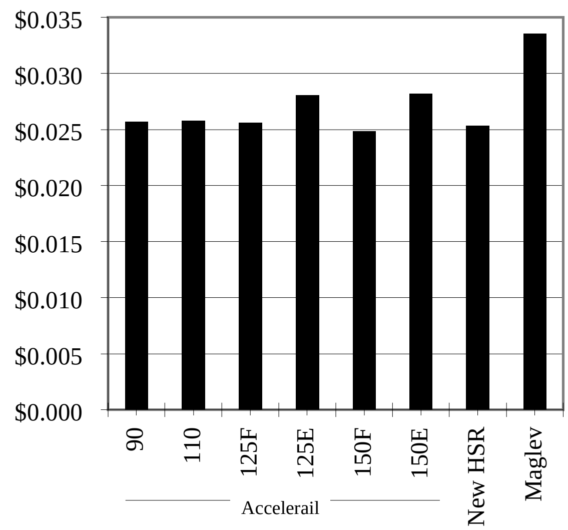


Figure Chapter 7 -17
Transportation Expense per Passenger-Mile (Chicago—Detroit Example)



Transportation expenses (Figure Chapter 7 -17) embody the relative operating efficiencies and passenger volumes of the options. Electrified Accelerail cases incur higher unit fuel costs (based on the assumption of constant petroleum prices), which New HSR can counteract with crew cost savings based on higher patronage and train speeds. In corridors outside the heavily traveled California and Northeast corridors, Maglev was assumed to use two-car trains and therefore has higher crew and energy expense levels than other options.[10]

Passenger Traffic and Services and **General and Administrative** expenses (Figure Chapter 7 -18 and Figure Chapter 7 -19) are rightfully independent of technology and generally decline as
passenger volumes increase. Marked declines for New High-Speed Rail and Maglev in

[10] Higher fares, justified in part by greater frequencies, yield revenues that more than offset these costs. With regard to energy, Maglev has somewhat higher unit energy costs in all corridors. Yet despite its very high speeds and use of energy for suspension as well as propulsion, Maglev's energy costs are by no means orders of magnitude higher than those for steel wheel options. Light in weight and unburdened by the structural standards mandated in mixed freight/passenger railroad operations, Maglev generates very high passenger-to-weight ratios, overcoming much of its energy disadvantage.

California and the Northeast Corridor show the beneficial effects of huge traffic increases on these accounts.

Figure Chapter 7 -18
Passenger Traffic and Services Expense Per Passenger-Mile (Chicago—St. Louis Example)

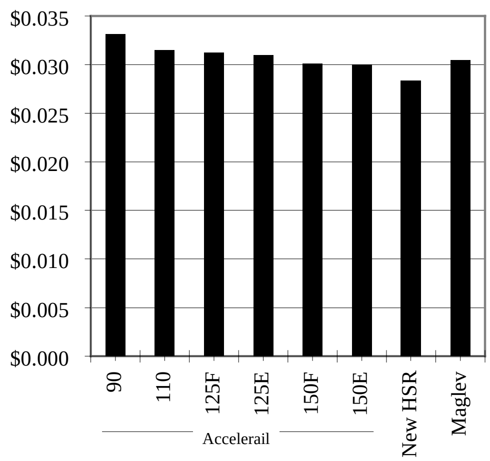
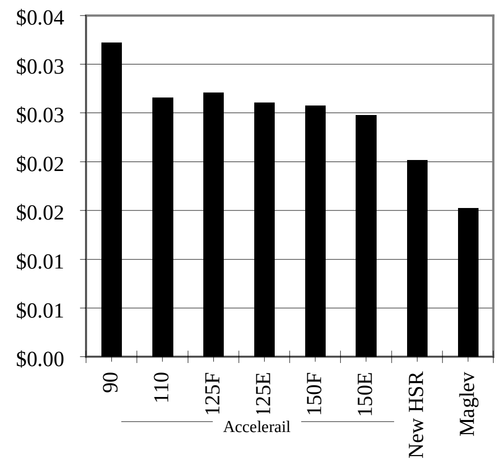


Figure Chapter 7 -19
General and Administrative Expense Per Passenger-Mile (California North/South Example)



Synthesis: Investments and Operating Results

In the most elemental terms, HSGT's ability to perpetuate itself (by providing a contribution over and above its continuing investment needs) depends on two things:

- The **volume** of traffic that it generates, measured in passenger-miles; and
- The difference, or **unit margin**, between the fare yield and operating expense per passenger-mile.

In regard to margins, the comparative performance of the illustrative corridors (Figure Chapter 7 -20) depends on two largely independent factors: the competitive situation versus other modes, which limits allowable prices; and the inherent efficiencies of the cases, which reflect many variables treated above. **A very efficient operation can have low unit margins,** as exemplified in the California North/South corridor's performance among the New HSR cases.

The reasons for California North/South's relatively poor unit margins become clear in a comparison with the Northeast Corridor (Figure Chapter 7 -21) for New HSR. California's comparatively low per-passenger-mile yield—caused by such differences in market conditions as the importance of low-fare air carriers, the distance between the two largest

Figure Chapter 7 -20
Unit Margin for New HSR in Nine Illustrative Corridors
(Year 2020)

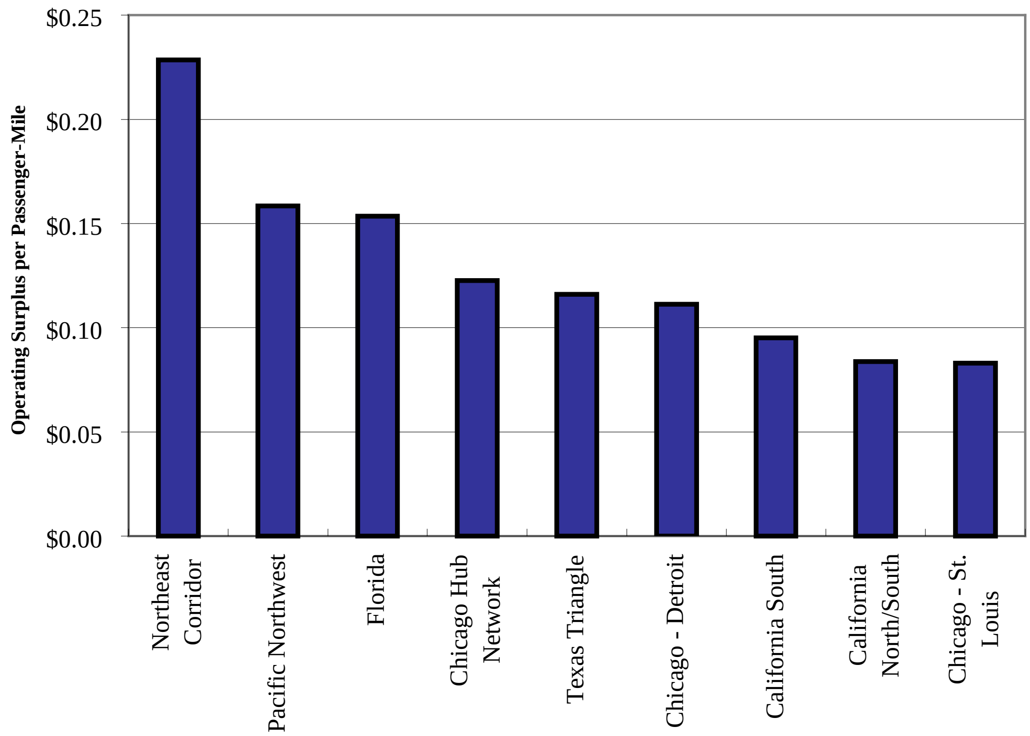
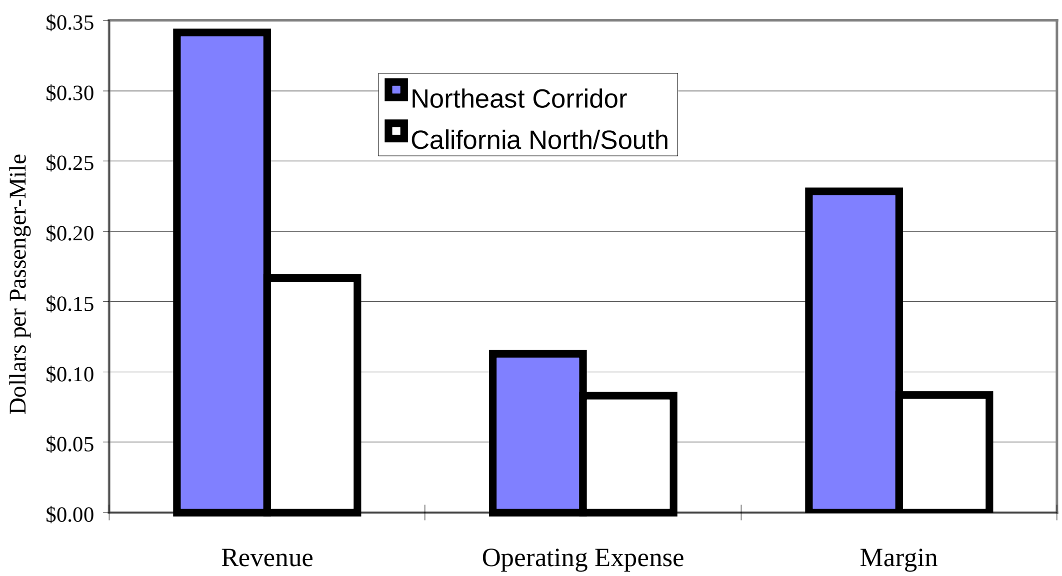


Figure Chapter 7 -21
Comparison of Unit Margin Components:
New HSR in the Northeast and California North/South Corridors

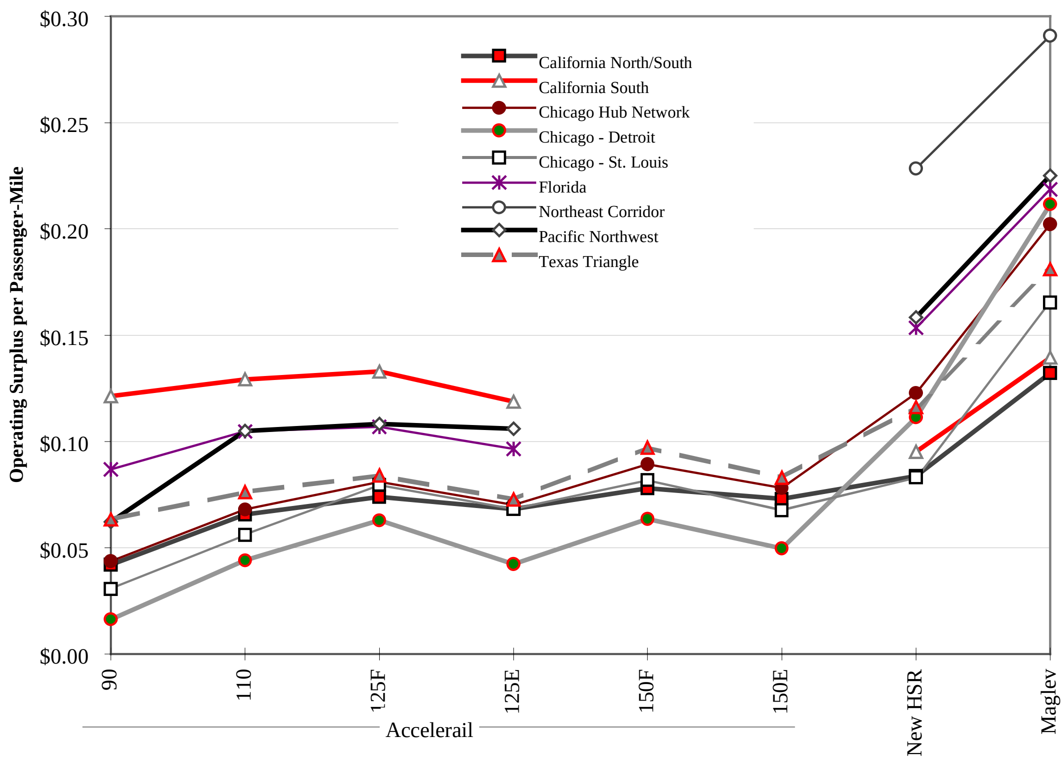


metropolitan areas, and New HSR's resulting inability to compete head-to-head with air on total trip times—far overshadows the effect of better operating efficiencies and lower unit expenses on the Bay Area—Los Angeles—San Diego route.

Figure Chapter 7 -22 indicates that the illustrative corridors, taken together, change similarly from one option to another. The basic trends include:

- Improved margins in the **lower-speed Accelerail ranges** (90 to 110 to 125F) reflect unit cost reductions in virtually all corridors, and fare yield improvements in some.
- Within the **125E to 150E** range of Accelerail options, fare yields are relatively constant and the changes in unit margin reflect operating expense fluctuations.
- Fare yields generally rise, and O&M expenses decrease in most corridors, between **150E and New HSR,** thus causing a rise in unit margins.

Figure Chapter 7 -22
Unit Margins by Corridor, Year 2020



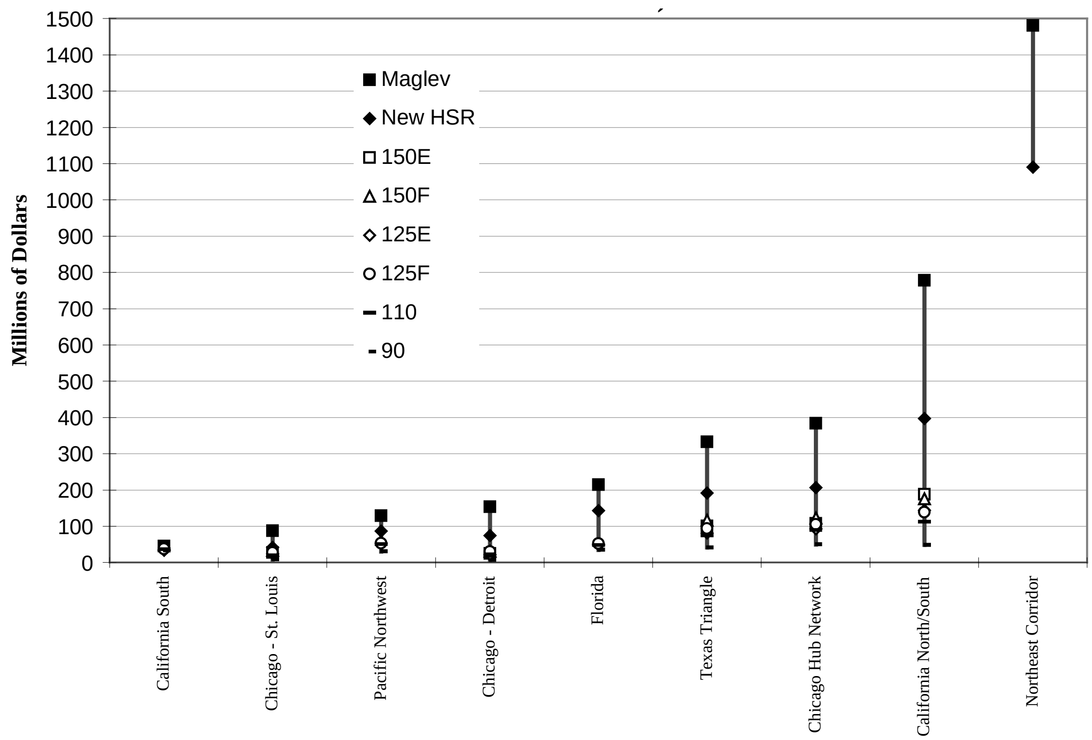
- **Maglev** shows markedly improved unit margins over New HSR, but the reasons differ among corridors, as shown in Table Chapter 7 –2. **In the highest-volume Northeast Corridor and California North/South corridors, Maglev's heavy passenger volumes and assumed technological efficiencies combine to produce dramatically reduced unit expenses over New HSR.** These economies do not appear, however, in lower volume operations. In all corridors, Maglev—with its higher frequencies and unmatched trip-time performance—commands much higher fares, accounting for most of the margin improvement in lower-volume cases.

Table Chapter 7 –2
Analysis of Difference in Unit Margins between New HSR and Maglev in Selected Corridors

	Difference in unit margin	Percent of difference from revenue changes	Percent of difference from O&M changes
California North/South	$0.048	65%	35%
Chicago - Detroit	$0.100	89%	11%
Chicago - St. Louis	$0.082	87%	13%
Chicago Hub Network	$0.079	99%	1%
Florida	$0.065	97%	3%
Northeast Corridor	$0.040	74%	26%
Texas	$0.065	100%	0%

The annual operating surplus for each case can be regarded (for some analytical purposes) as the product of the unit margin and the passenger-miles. Figure Chapter 7 -23—arraying the corridors in order of travel volumes—demonstrates not only the considerable variance in operating surpluses within each corridor, but also the degree to which unit margins can predominate over traffic levels in determining the outcome. The Northeast Corridor, generating traffic volumes similar to (or less than) those of California, outshines the latter—and all other corridors—in annual operating surplus for reasons analyzed above. Most other corridors show surpluses in the $0 to $100 million range for Accelerail, and from $50 to $200 million for New HSR and Maglev. California's performance, of course, covers a wide range because of the divergent products offered by the various options, a natural consequence of the challenging routing and sheer size of that State.

Figure Chapter 7 -23
Range of Annual Operating Surpluses by Corridor
(Year 2020: Corridors Are Arrayed in Order of Ascending Passenger-Miles for New HSR.)



The definition of partnership potential in Chapter 3 requires a case to do more than simply cover its annual expenses out of annual revenues. The present value of the future operating surpluses must cover at least the present value of the continuing investments.[11] How do the illustrative corridors fare on this measure?

As shown in Table Chapter 7 –3, all the illustrative cases—with one exception, Chicago–Detroit at 90 mph—meet the "surplus less continuing investments" standard for partnership potential. Virtually all the cases are projected to cover their operating and maintenance expenses and continuing investment needs given the fare levels, unit costs, and partnerships described herein.

[11] The continuing investments range from approximately 5 to 18 percent of the initial investment for Accelerail 90 and 110, down to 2 to 8 percent of the higher-performance Accelerails, New HSR, and Maglev. These amounts are present values of investments that occur throughout the 40-year planning period.

Table Chapter 7 –3
Surplus (Deficit) After Continuing Investments by Case
(Millions of Dollars, 40-Year Present Values) (Shaded Cases Were Not Analyzed)

	Accelerail						New HSR	Maglev
	90	110	125F	125E	150F	150E		
California North/South	$276	$714	$870	$864	$1,151	$1,232	$2,489	$5,584
California South	$206	$241	$252	$214			$176	$284
Chicago Hub Network	$257	$560	$708	$584	$835	$690	$1,371	$2,974
Chicago - Detroit	($16)	$114	$189	$82	$184	$115	$457	$1,160
Chicago - St. Louis	$33	$111	$169	$131	$215	$154	$218	$618
Florida	$152	$244	$270	$239			$915	$1,552
Northeast Corridor							$8,277	$11,607
Pacific Northwest	$181	$333	$359	$324			$521	$859
Texas	$195	$456	$586	$486	$797	$646	$1,168	$2,453

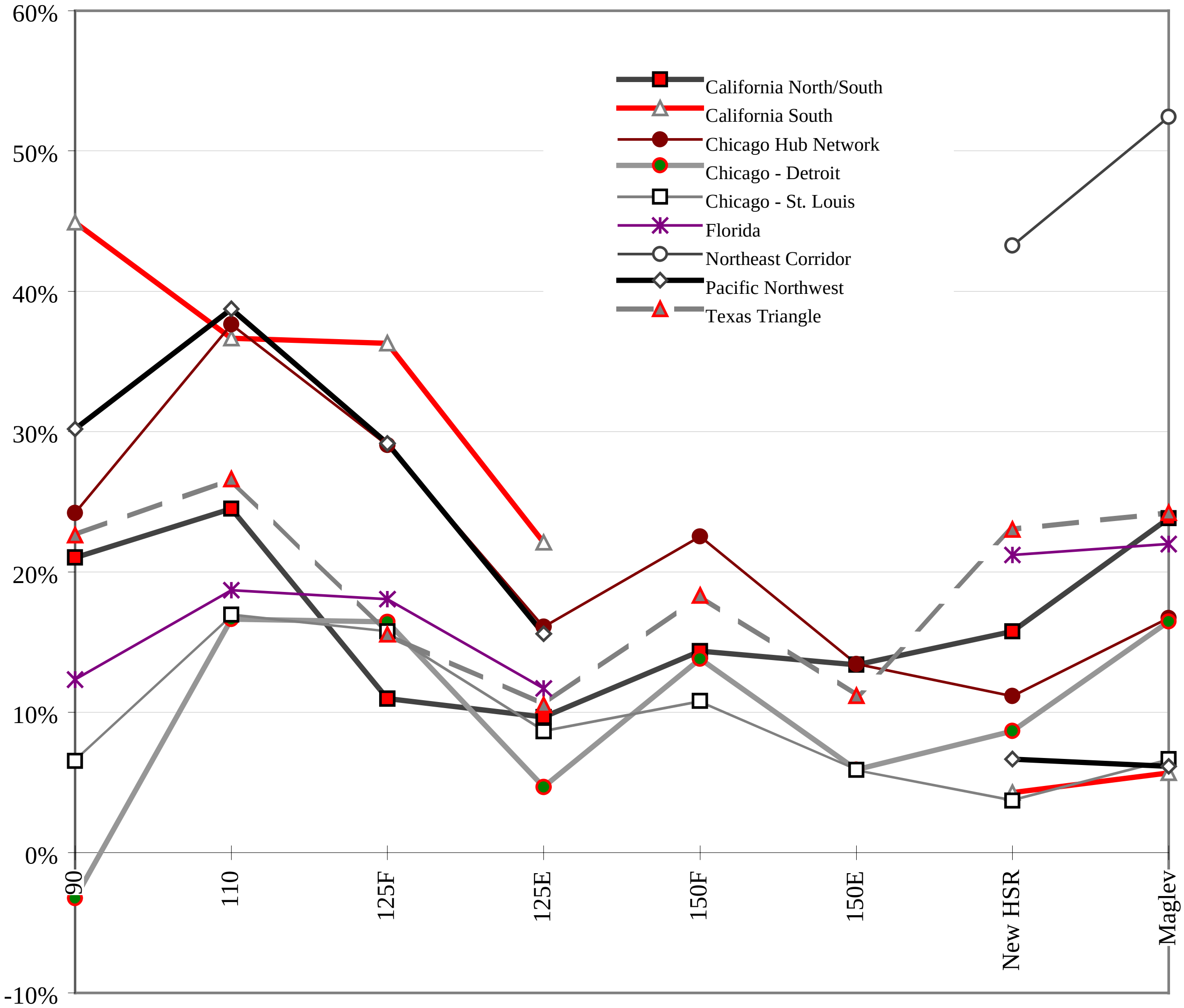
These surplus amounts must come into comparison with the initial investments required for each case (Table Chapter 7 –4).

Table Chapter 7 –4
Initial Investment by Case
(Millions of Dollars)

	Accelerail						New HSR	Maglev
	90	110	125F	125E	150F	150E		
California North/South	$1,314	$2,914	$7,931	$8,948	$8,024	$9,203	$15,792	$23,430
California South	$459	$657	$694	$969			$4,112	$5,006
Chicago Hub Network	$1,062	$1,487	$2,438	$3,628	$3,708	$5,137	$12,285	$17,787
Chicago - Detroit	$484	$688	$1,151	$1,748	$1,329	$1,945	$5,284	$7,044
Chicago - St. Louis	$500	$657	$1,074	$1,516	$1,991	$2,617	$5,900	$9,291
Florida	$1,235	$1,305	$1,494	$2,041			$4,316	$7,054
Northeast Corridor							$19,127	$22,137
Pacific Northwest	$598	$859	$1,233	$2,076			$7,819	$13,980
Texas	$863	$1,714	$3,767	$4,613	$4,349	$5,780	$5,071	$10,127

As shown in Figure Chapter 7 -24, surpluses could cover about half of the initial investment in the Northeast Corridor; over one third of the initial investment in certain California South, Chicago Hub Network, and Pacific Northwest cases; and up to one quarter of the initial investment in California North/South and the Texas Triangle.

Figure Chapter 7 -24
Percent of Initial Investment Covered by Surplus After Continuing Investments



Despite local differences, certain general trends emerge from Figure Chapter 7 -24. Almost universally, Accelerail 110 provides better coverage than Accelerail 90 because the former's revenue-producing potential outweighs its incremental investment. As investment needs increase and performance improvements moderate in higher-level Accelerail cases, surpluses cover a declining percentage of the investment (with some adjustments due to electrification). This trend typically reverses itself with New HSR and particularly with Maglev, due to their ability to generate higher unit and total margins.

Figure Chapter 7 -24 epitomizes the purely commercial projections in that it gauges the maximum proportion of each corridor's initial investment that might be financed on the basis of future operating surpluses, under all the assumptions governing this study. Many cases—mainly lower-speed Accelerail technologies and new Northeast Corridor systems—show promise of financing significant portions (one-fifth to one-half) of their initial capital costs. While potentially encouraging the formation of private/public partnerships, the projections displayed in Figure Chapter 7 -24 do not meet the traditional private-sector criterion for "commercial feasibility."

Wherever possible, the study assumptions were intended to maximize the percentages displayed in Figure Chapter 7 -24. In particular, the fare-setting protocols[12] tended to maximize operating surpluses. This practice allowed the simulated cases to show optimal—although not necessarily successful—results from a commercial perspective, in keeping with the literal intent of Congress to explore HSGT's "commercial feasibility." However, this fiscally cautious approach did not necessarily maximize all ratios of benefits to costs.

BENEFIT/COST COMPARISONS

As Chapter 3 explains, commercial feasibility is only one basis for calculating the worth of HSGT. Other important comparisons are total benefits with total costs; benefits to HSGT users with costs borne by users; and benefits to the public at large with publicly-borne costs.

Total Benefits Versus Total Costs

Table Chapter 7 –5 shows the amount by which total benefits are projected to exceed (or fall short of) total costs. In most of the illustrative cases, HSGT's total benefits exceed total costs; the projected value of the excess is generally higher in the Accelerail than in the New HSR and Maglev options.

As shown in Figure Chapter 7 -25, each HSGT technology would provide a favorable ratio of total benefits to total costs in at least one corridor: New HSR, for example, is projected to have ratios equal to or greater than 1.0 in four of the nine illustrative corridors covered in this chapter, and Maglev in two of the nine. Likewise, each illustrative corridor would provide favorable ratios of total benefits to total costs in one or more HSGT technologies.

The projections suggest that—subject to the assumptions and scope of this study—the less expensive technologies, relying on upgraded existing rail lines and freight railroad

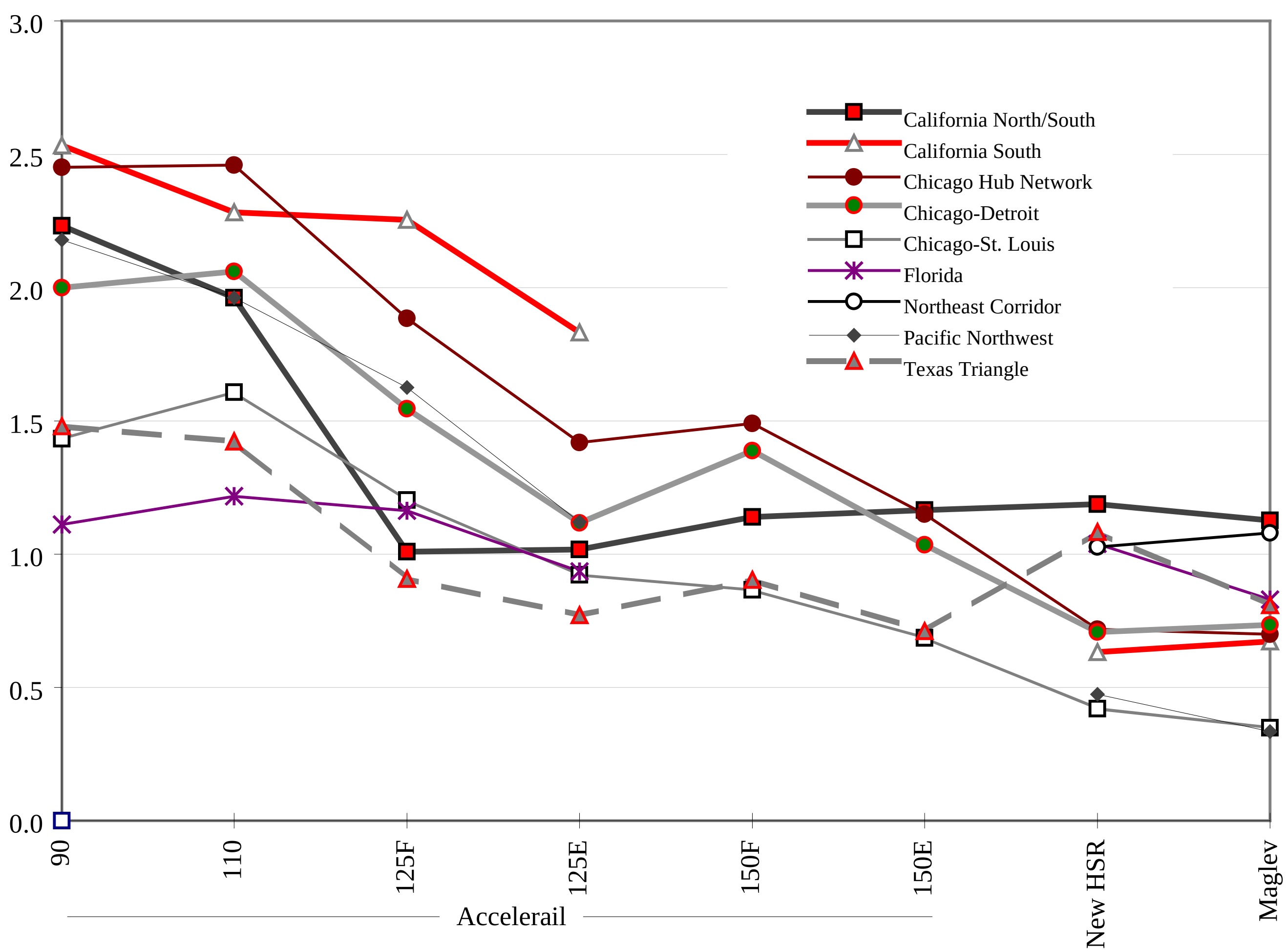
[12] See Chapter 4.

cooperation, could typically provide higher ratios of benefits to costs than the very high-speed options, which may offer higher benefits but would ordinarily cost much more.

Table Chapter 7 –5: Total Benefits Less Total Costs (Millions of Dollars)

	Accelerail							
	90	**110**	**125F**	**125E**	**150F**	**150E**	**New HSR**	**Maglev**
California North/South	$3,228	$4,247	$93	$191	$1,383	$1,889	$3,670	$3,422
California South	$1,329	$1,370	$1,384	$1,184			($1,715)	($1,827)
Chicago Hub Network	$3,194	$4,023	$3,280	$2,118	$2,466	$997	($3,984)	($5,951)
Chicago-Detroit	$979	$1,300	$902	$277	$735	$92	($1,805)	($2,098)
Chicago-St. Louis	$350	$632	$294	($151)	($324)	($974)	($3,810)	($6,485)
Florida	$195	$402	$335	($173)			$210	($1,402)
Northeast Corridor							$648	$2,128
Pacific Northwest	$1,447	$1,434	$1,168	$333			($4,622)	($10,028)
Texas Triangle	$749	$1,122	($441)	($1,318)	($520)	($2,015)	$570	($2,302)

Figure Chapter 7 -25
Ratios of Total Benefits to Total Costs



With the exception of Accelerail 90 in Chicago—Detroit, which generates an operating deficit rather than a surplus, all the cases in Figure Chapter 7 -25 with ratios of 1.0 or greater fulfill this study's threshold requirements for partnership potential.[13]

Benefits to HSGT Users Versus Costs Borne by Users

As displayed in Table Chapter 7 –6 and Figure Chapter 7 -26, HSGT users invariably enjoy an excess of benefits over costs (i.e., the users' consumer surplus described in Chapter 6). This excess may be regarded as a subsidy enjoyed by HSGT users, to the extent that the publicly-borne costs exceed the benefits to the public at large in a given case.

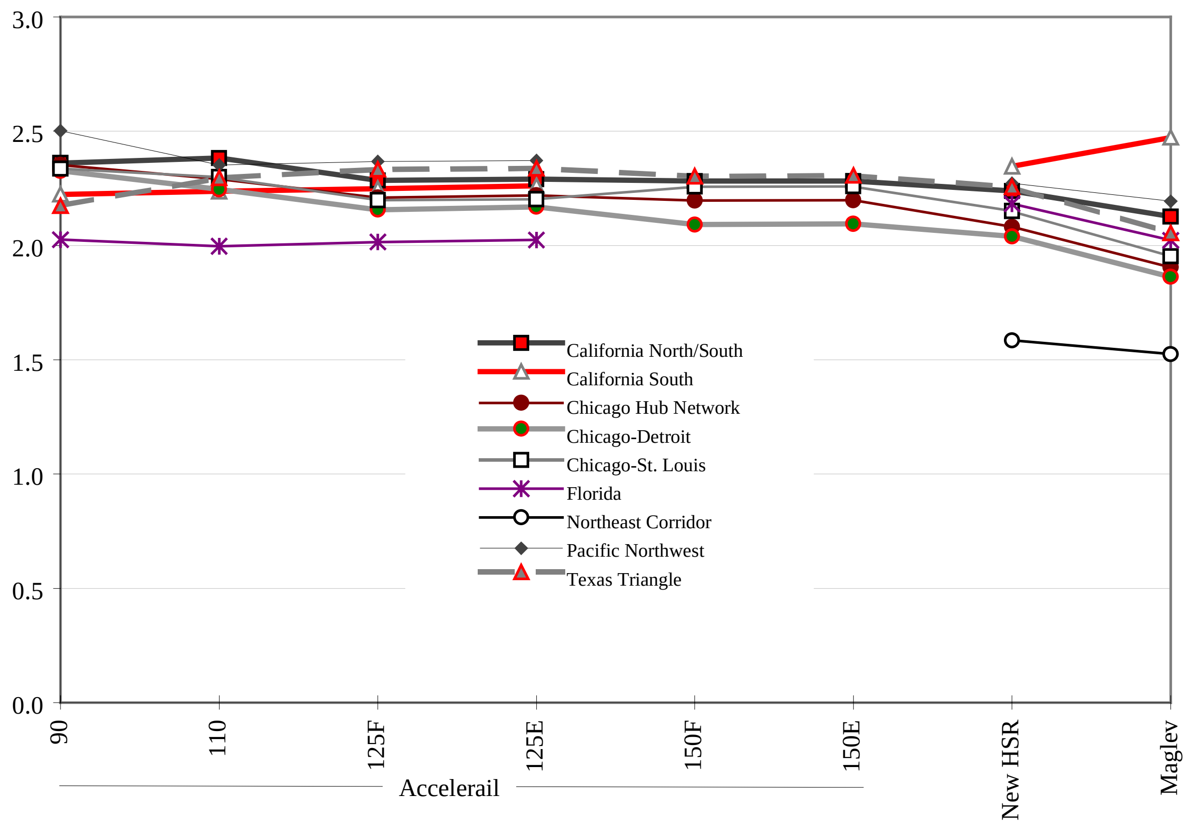
Table Chapter 7 –6
Benefits to HSGT Users Less Costs Borne by Users
(Millions of Dollars)

	Accelerail							
	90	**110**	**125F**	**125E**	**150F**	**150E**	**New HSR**	**Maglev**
California North/South	$2,153	$3,055	$3,374	$3,745	$3,913	$4,396	$7,688	$10,324
California South	$752	$807	$827	$843			$976	$1,249
Chicago Hub Network	$1,888	$2,363	$2,392	$2,454	$2,594	$2,606	$3,478	$4,491
Chicago-Detroit	$635	$811	$804	$837	$813	$820	$1,380	$1,721
Chicago-St. Louis	$459	$642	$649	$662	$799	$805	$1,027	$1,225
Florida	$681	$787	$847	$886			$2,435	$2,781
Northeast Corridor							$7,861	$8,538
Pacific Northwest	$1,216	$1,304	$1,363	$1,379			$1,899	$2,310
Texas Triangle	$1,050	$1,814	$2,116	$2,146	$2,395	$2,412	$3,654	$4,543

[13] As defined in this report, "partnership potential" is the apparent capacity of an HSGT corridor to draw the private and public sectors together in planning, negotiations, and, conceivably, project implementation. To exhibit partnership potential, the projections for an HSGT technology in a particular corridor must satisfy at least the following two conditions: First, private enterprise must be able to run the corridor—once built and paid for—as a completely self-sustaining entity; in other words, the case must generate a projected surplus after continuing investments. Second, the total benefits of an HSGT corridor must equal or exceed its total costs. This report uses "partnership potential" as an indicator of the aggregate financial and economic impacts of HSGT alternatives in a set of illustrative corridors. Detailed State studies of individual corridors would benefit from additional evaluation measures as well as site-specific investigations and data. Thus, while "partnership potential" may offer useful insights in assessing the likelihood of HSGT development by State and local governments and their private partners, it does not constitute an express or implied criterion for Federal approval or funding. For further particulars on "partnership potential," the reader is referred to Chapters 3 and 6.

The ratios in Figure Chapter 7 -26 (minus one) equate to the ratio of consumer surplus to system revenues. [14]

Figure Chapter 7 -26
Ratios of Benefits to HSGT Users, to Costs Borne by Users



Benefits to the Public at Large Versus Publicly-Borne Costs

For each illustrative case, Table Chapter 7 –7 shows the excess (or shortfall) of benefits to the public at large in comparison with publicly-borne costs, and Figure Chapter 7 -27 depicts the corresponding ratios.

As portrayed in Figure 7-27, benefits to the public at large exceed the publicly-borne costs in only about one-quarter of the illustrative HSGT cases. These all occur in the

[14] Cf. Chapter 6, which provides the equation for this ratio as:

(System Revenues plus Users' Consumer Surplus)/ System Revenues

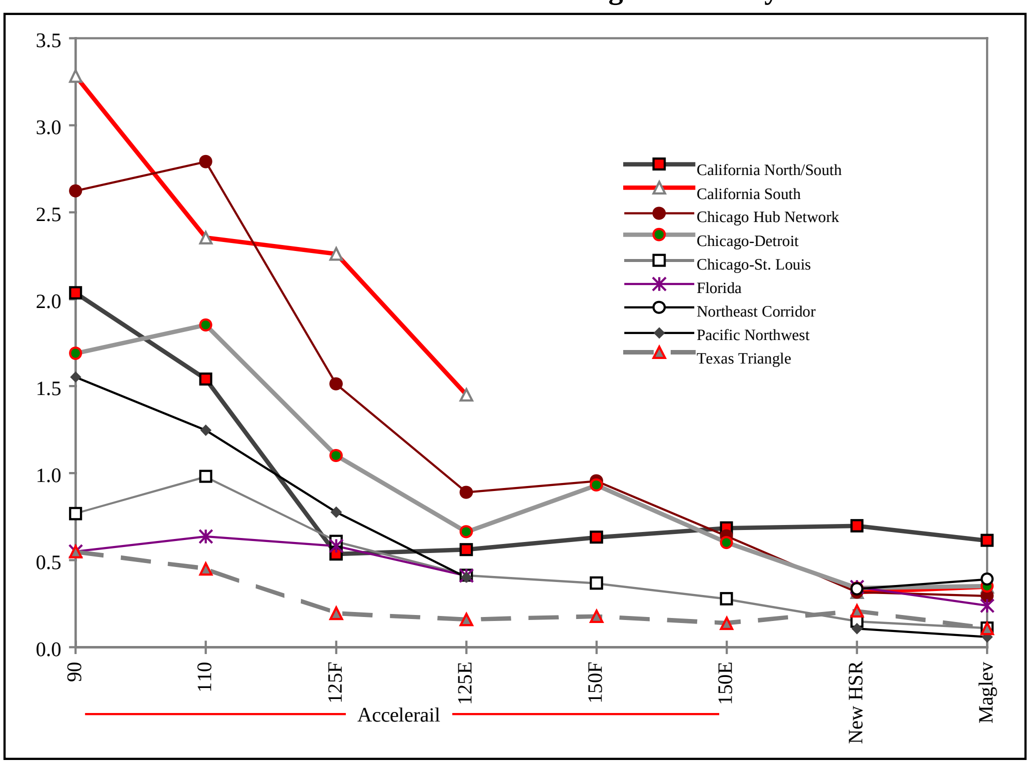
This is algebraically equivalent to:

(System Revenues/System Revenues), or one, plus (Users' Consumer Surplus/System Revenues).

Table Chapter 7 –7
Benefits to the Public at Large Less Publicly-Borne Costs
(Millions of Dollars)

	Accelerail							
	90	**110**	**125F**	**125E**	**150F**	**150E**	**New HSR**	**Maglev**
California North/South	$1,075	$1,192	($3,280)	($3,554)	($2,530)	($2,507)	($4,018)	($6,902)
California South	$578	$563	$557	$341			($2,691)	($3,076)
Chicago Hub Network	$1,306	$1,660	$888	($336)	($128)	($1,609)	($7,461)	($10,442)
Chicago-Detroit	$344	$488	$98	($560)	($79)	($729)	($3,184)	($3,819)
Chicago-St. Louis	($109)	($10)	($354)	($812)	($1,123)	($1,779)	($4,837)	($7,710)
Florida	($486)	($385)	($512)	($1,059)			($2,225)	($4,183)
Northeast Corridor							($7,213)	($6,410)
Pacific Northwest	$231	$130	($194)	($1,046)			($6,521)	($12,338)
Texas Triangle	($301)	($692)	($2,557)	($3,464)	($2,916)	($4,427)	($3,084)	($6,845)

Figure Chapter 7 -27
Ratio of Benefits to the Public at Large to Publicly-Borne Costs



Accelerail options. Benefits to the public at large do not exceed publicly-borne costs for any Maglev, New HSR, or Accelerail 150 options. Such effects on users versus the public at large merit further attention in State analyses of HSGT and in reaching decisions on public funding of high-speed rail and Maglev.

When benefit-cost analysis of HSGT is approached in accordance with Figure Chapter 7 -27, lower-cost HSGT options appear to generate higher ratios of benefits to costs—a trend analogous to that of Figure Chapter 7 -25 for total benefits and costs. Along with this finding, public benefit-cost analysis may yield valuable information necessary for fully apprising decision makers and the public of the value of HSGT options.

However, cases where public benefits do not exceed public costs need not be ruled out for consideration by States or private concerns. In such cases, prospective transfer effects, mobility concerns, and environmental factors may justify further consideration, even though such impacts did not enter into the benefit/cost calculation for this analysis.[15] The state-specific localized benefits from HSGT corridors further illustrate why it is appropriate to focus on State, local, or private financing rather than Federal financing for these projects.

Indeed, in contrast with a nationwide study such as this one, individual State studies can more closely examine specific corridors, with greater sensitivity to the State's underlying reasons for considering HSGT. Such detailed examination may favor a non-HSGT solution, Accelerail, New HSR, or Maglev. A State, for example, may wish to provide a high-reliability, high-frequency HSGT option and may believe that only New HSR or Maglev can offer a sufficient quality of service. Likewise, a State may place an extraordinarily high value on environmental benefits, and would seek the HSGT option that maximizes those benefits. A State may regard the cooperation of its freight railroads as impossible to achieve, thereby precluding Accelerail; or a State may perceive Accelerail as the ideal compromise between its fiscal constraints and its desire for improved intercity transport. Financing issues, moreover, would call for detailed scrutiny, since the absolute size of the required initial investment (in conjunction with the available resources of the private and public participants) will heavily influence the feasibility of HSGT proposals. Finally, the States and localities, through their intermodal planning processes, are uniquely qualified to judge the synergy between HSGT corridor development and the enhancement of regional public transit services, highways, and airports. Taken together, these examples underscore the importance of site-specific, State-sponsored studies to the definitive characterization of HSGT and other intercity transport options.

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[15] See Chapter 6.

CHAPTER 8
SPECIALIZED ANALYSES

This chapter presents the results of specialized analyses that offer further insights into the economics and partnership potential of HSGT for America in the 21st century. Specifically, the following sections delve into these questions:

- What happens when an HSGT corridor is extended to a new terminus?
- What happens when "hybrid" HSGT cases, involving more than one technology, are simulated?
- And finally—what happens when key assumptions are altered?

EXTENSIONS OF HSGT

All the illustrative cases described in Chapter 7 would constitute essentially new services, either starting from scratch, substituting for conventional Amtrak operations, or displacing older HSGT. Far different would be the case of an **extension of HSGT service**, in which the ability to generate substantial traffic volumes over long distances might afford special opportunities for partnership potential.

The Empire Corridor (New York to Albany, Syracuse, Rochester, and Buffalo) and the Southeast Corridor (Washington, D.C. to Richmond, Raleigh, Greensboro, and Charlotte) would be natural extensions of Northeast Corridor HSGT services. Through rail passenger services from New York City via Washington to the Southeast developed over a century ago and persisted as transportation evolved in the subsequent decades. While historical factors traditionally impeded direct rail passenger service between the Northeast and Empire corridors, the density of population in both corridors would encourage through traffic there as well.

Either of these extensions would increase the traffic levels on the Northeast Corridor itself, because through passengers from south of Washington and north and west of New York would need to use the Northeast Corridor to access major Northeastern cities.[1] In this manner, traffic densities on the Northeast Corridor would increase, thus creating synergistic ridership, revenue, expense, and income effects that might redound to a single HSGT operator's profitability.

Recognizing the special opportunities posed by Southeast and Empire extensions of HSGT in the Northeast Corridor, this study accorded them exceptional treatment based on the following principles:

[1] In addition, but of lesser importance, any additional Northeast Corridor frequencies necessary to serve the aforementioned through traffic could boost internal Northeast Corridor ridership.

- The study addressed two Northeast Corridor-related systems only[2]:
  - Southeast Corridor plus Northeast Corridor; and
  - Empire Corridor plus Northeast Corridor.
- For analytical convenience, each system was assumed to be operated by a **single HSGT entity**: the Northeast Corridor operator.[3]

Technologies in the extensions were matched with technologies in the Northeast Corridor as follows:

- Accelerail 110 (Southeast) and 125F (Empire) with Amtrak's existing[4] electrified Accelerail service in the Northeast Corridor.[5]
- New HSR in the extensions with a hypothetical future New HSR system in the Northeast Corridor.
- Maglev in the extensions with a hypothetical future Maglev system in the Northeast Corridor.

Traffic Base

All the options in the Northeast Corridor extensions draw much of their strength from the synergies inherent in the underlying passenger flows. Specifically, for each extension, the traffic base[6] consists of three parts—(1), (2)(a), and (2)(b) below:

(1) Traffic internal to the extension—for example, between Buffalo and Albany, or between Raleigh and Richmond;

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[2] A combination of HSGT in all three corridors—Northeast, Empire, and Southeast—is conceivable but was not modeled, nor were other potential Northeast Corridor HSGT extensions (e.g., Hartford/Springfield and Harrisburg).

[3] This is a critical institutional assumption; others are conceivable but could yield far different results. Regardless of the institutional framework, issues would inevitably arise over the proper allocation of through-traffic revenues and expenses between the Northeast Corridor and the extension. The treatment in this report does not address those issues and institutional options, which the States, Amtrak, and others may someday wish to explore in depth.

[4] The service capabilities over the Northeast Corridor in the Accelerail extension cases are assumed to be substantially the same as those currently in effect, except that (a) electrification from New Haven to Boston is assumed to be completed and (b) the new "American Flyer" trainsets are assumed to be in service for trips strictly within the Northeast Corridor alone. Both of these exceptions are to be in place by the year 2000, and neither of these exceptions would have a sizable impact on through traffic between the Northeast Corridor and the extensions.

[5] Due to time and resource limitations, and the complexity and length of these incremental corridors, this study addressed only one typical Accelerail option for each. The States may wish to address the full range of options in any subsequent studies.

[6] The term "traffic base" refers to the 1993 traffic flows by existing modes (see Chapter 5).

(2) Cross-traffic that makes use of both the extension itself and the Northeast Corridor—for example, between Philadelphia and Albany, or between Greensboro and New York City. This cross traffic consists of two components:

(a) Passenger-miles accumulated on the extension itself; and

(a) Passenger-miles accumulated on the Northeast Corridor.

The "synergy bonus" consists of item (2)(b) above, since the benefits from increased Northeast Corridor traffic come at relatively low cost. Both the Empire and Southeast Corridors would, indeed, generate significant portions of their transportation production on the Northeast Corridor, as shown in the base traffic data in Figure Chapter 8 -1 and Figure Chapter 8 -2.

Figure Chapter 8 -1
Composition of Empire Corridor Traffic Base

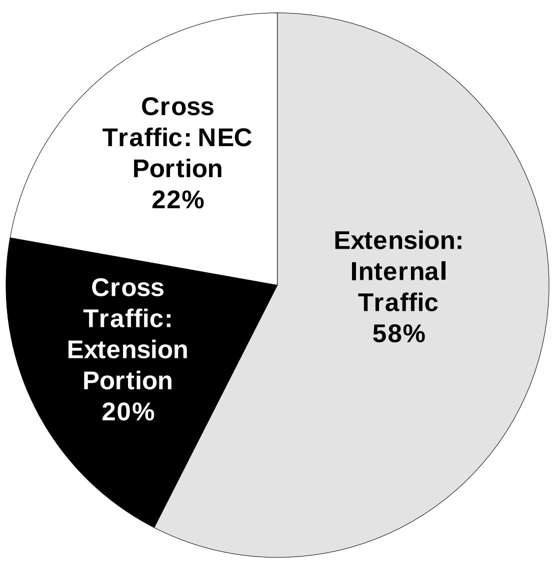
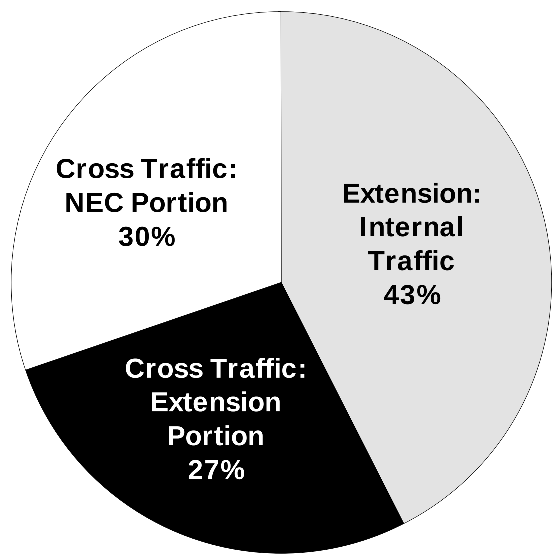


Figure Chapter 8 -2
Composition of Southeast Corridor Traffic Base



The variations in the traffic base between the Empire and Southeast Corridors reflect their different spatial configurations (see Figure Chapter 8 -3 and Figure Chapter 8 -4.) New York City is supreme as a traffic generator; but the Empire Corridor accesses New York directly and is not positioned to divert heavy traffic from New York State to New England via New York City and the "North End" of the Northeast Corridor. Thus the prime opportunity for Empire/Northeast Corridor through traffic is from upper New York State points to New Jersey and Philadelphia, a relatively short distance (about 90 miles) on the Northeast Corridor. By contrast, traffic from the Southeast Corridor to New York, New

Jersey, and Philadelphia must traverse some 150-225 miles of Northeast Corridor trackage and generate the consequent passenger-miles. Factors such as these would account for some of the different traffic characteristics in the Empire versus the Southeast Corridor—for example, an average trip length of 295 miles for Accelerail 110 in the Southeast Corridor, versus 237 miles for Accelerail 125F in the Empire Corridor.

Figure Chapter 8 -3
Empire Corridor[7]

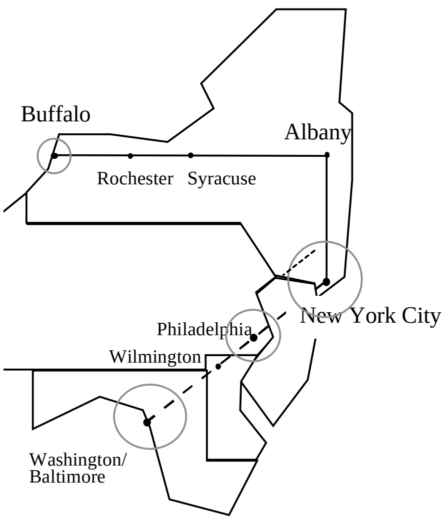
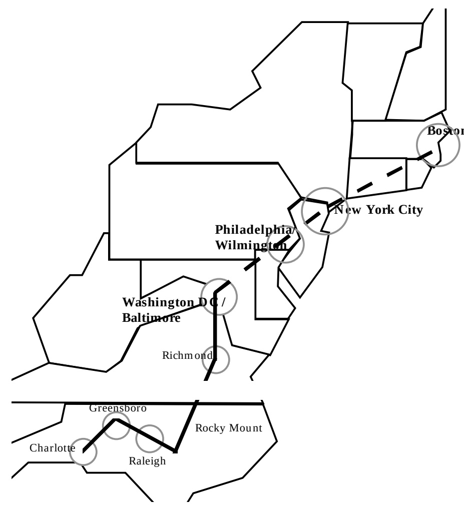


Figure Chapter 8 -4
Southeast Corridor



Extensions of Existing Accelerail Service in the Northeast Corridor

Only the Accelerail options constitute "extensions" in the strict sense of that term, since only they would "extend" a Northeast Corridor service that currently exists.[8] The Accelerail projections for the Empire and Southeast Corridors therefore address a fundamental question—how would the addition of Southeast or Empire Corridor service to Northeast Corridor service affect a single HSGT entity?—by effectively summing the following:

- All investment requirements, revenues, expenses, and benefits pertaining to the **extension proper**, plus

[7] Because of the extreme circuity involved, this study did not address city pair markets linking the Empire Corridor with Northeast Corridor points north and east of the New York CMSA.
[8] Or will be in place by the year 2000; see footnote 4.

- Identifiable investment requirements, revenues, expenses, and benefits arising **on the Northeast Corridor proper** as a **direct result of through traffic** between the Northeast Corridor and the extension.

Table Chapter 8 -1 thus approximates the effects of adding Empire or Southeast Corridor Accelerail service to a Northeast Corridor operation similar to that of today.

Table Chapter 8 -1
Accelerail Projections for Northeast Corridor Extensions

HSGT in 2020:	**EMPIRE CORRIDOR Accelerail 125F (Extension)**	**SOUTHEAST CORRIDOR Accelerail 110 (Extension)**
Line-haul travel time, hours, New York-Buffalo	5.2	
Line-haul travel time, hours, Charlotte-Washington		5.7
Trains per day in each direction, New York-Buffalo	50	
Trains per day in each direction, Charlotte-Washington		27
Average fare per passenger-mile (dollars)	0.192	0.176
Passengers, Millions of Trips (2020)	9.4	5.7
Passenger-Miles, Millions (2020)	2,229	1,689
Average trip length (miles)	237	295
Projection Results (Dollar Amounts are Present Values in Millions for the Period 2000-2040)		
Surplus after continuing investments	**$1,473**	**$1,041**
Total benefits	**$9,681**	**$6,519**
Benefits to HSGT users:		
System revenues	$3,591	$2,561
Users' consumer surplus	$4,374	$2,550
Total benefits to HSGT users	$7,965	$5,110
Benefits to the public at large	$1,716	$1,409
Total costs	**$4,050**	**$2,567**
Components of total costs:		
Initial investment	$1,932	$1,047
O&M expense	$1,930	$1,389
Continuing investments	$188	$131
Incidence of total costs:		
Costs borne by users	$3,591	$2,561
Publicly-borne costs	$459	$7
Total benefits less total costs	**$5,631**	**$3,952**
Benefits to HSGT users less costs borne by users	$4,374	$2,550
Benefits to the public at large less publicly-borne costs	$1,257	$1,403
Ratio of total benefits to total costs	**2.39**	**2.54**
Ratio of benefits to HSGT users, to costs borne by users	2.2	2.0
Ratio of benefits to the public at large, to publicly-borne costs	3.7	[9]
Does this case meet the threshold tests for "partnership potential"?	YES	YES

Under this projection method, Accelerail in both extensions performs better, on a purely commercial basis, than comparable options in the illustrative corridors described in Chapter 7; furthermore, both extensions provide relatively high ratios of benefits to costs. Table Chapter 8 -2 summarizes these comparatively favorable projections for Accelerail in the Northeast Corridor extensions.

[9] Since the publicly-borne costs are projected to be nearly zero, this ratio would be inapplicable.

Table Chapter 8 -2
Accelerail Performance Comparison:
Northeast Corridor Extensions Versus All Other Illustrative Corridors

	Percentage of Initial Investment Covered by Surplus After Continuing Investments		Ratio of Total Benefits to Total Costs	
	Accelerail 110	**Accelerail 125F**	**Accelerail 110**	**Accelerail 125F**
Empire Corridor (Extension)		76%		2.5
Southeast Corridor (Extension)	99%		2.4	
Range of All Other Illustrative Corridors [10]	Between 17% and 39%	Between 11% and 36%	Between 1.1 and 2.5	Between 1.2 and 2.5

These results for the extensions clearly benefit from the "synergy bonus" described above. Figure 5 and Figure 6, in showing the annual passenger-miles (Year 2020) per route-mile of Accelerail infrastructure investment, clearly demonstrate how the cross-traffic between the Northeast Corridor and its extensions enhances the potential of Accelerail in the Empire and Southeast Corridors.

Figure Chapter 8 -6: Annual Passenger-Miles (Million) Per Upgraded Accelerail 110 Route-Mile

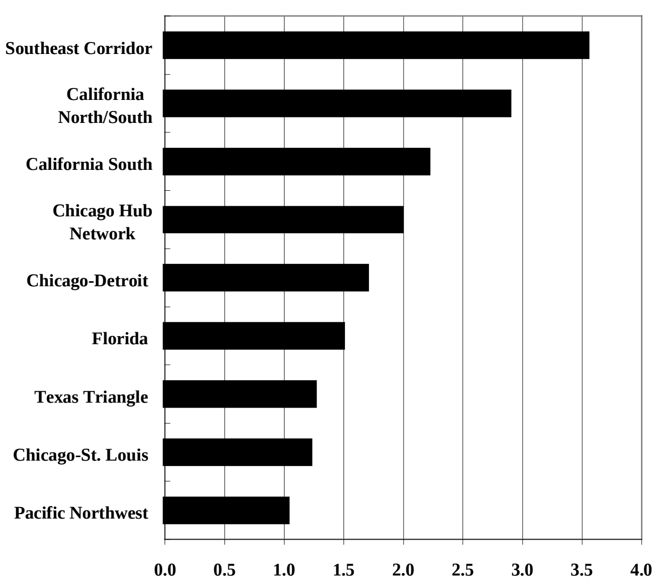
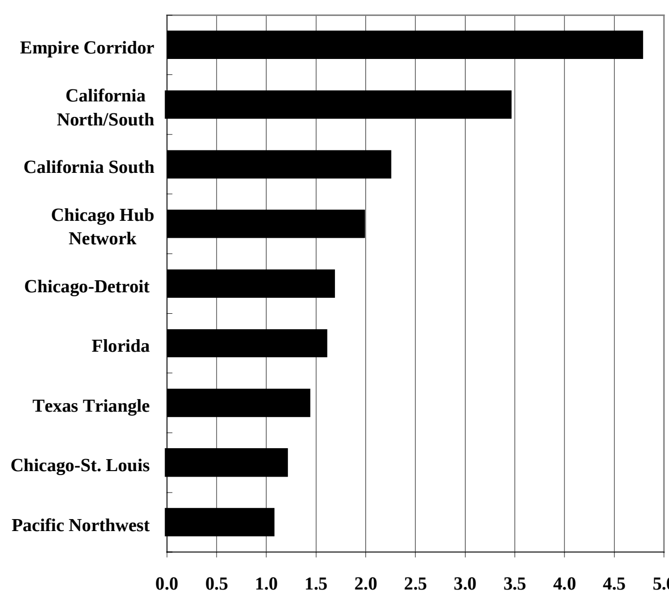


Figure Chapter 8 -5: Annual Passenger-Miles (Million) Per Upgraded Accelerail 125 Route-Mile



[10] See Chapter 7.

New HSR and Maglev Systems

Accelerail extensions in the Empire or Southeast Corridor were analyzed for their impacts on the operator of a pre-existing Northeast Corridor Accelerail service. Such an approach makes sense because the Northeast Corridor already enjoys Accelerail service. To characterize New HSR and Maglev in the Empire and Southeast Corridors, however, requires a more complex procedure since neither of these technologies exists in today's Northeast Corridor. Specifically, the study assumed that a single operator manages New HSR or Maglev as a integral system in the Northeast and Empire Corridors ("Empire/Northeast System"); or in the Northeast and Southeast Corridors ("Southeast/Northeast System"). The study then projected the requirements and performance, and the benefits and costs, of each integral system.

The results appear in Table Chapter 8 -4. Both New HSR and Maglev have partnership potential in the two systems, which are comparable in overall performance to the Northeast Corridor taken alone, and to the California Corridor (as exemplified in Table Chapter 8 -3):

Table Chapter 8 -3
Ratios of Benefits to Costs for New HSR and Maglev Systems

	Total Benefits to Total Costs		Benefits to the Public at Large, to Publicly-Borne Costs	
	New HSR	**Maglev**	**New HSR**	**Maglev**
Empire/Northeast System	1.0	1.0	0.3	0.3
Southeast/Northeast System	1.1	1.3	0.4	0.5
Northeast Corridor alone	1.0	1.1	0.3	0.4
California North/South	1.2	1.1	0.7	0.6

That these integral systems—each almost 900 miles in length—perform as well as (and, in the case of the Southeast/Northeast System, even better than) the heavily trafficked Northeast Corridor alone stems from two key factors. First, in both integral systems, the traffic levels attributable to origins and/or destinations outside the Northeast Corridor proper are approximately double those which might arise if Washington—Charlotte, or New York—Albany—Buffalo, existed in a population vacuum. (See Figure Chapter 8 -1 and Figure Chapter 8 -2.) So great is the "synergy bonus" that approximately 30 percent of the transportation production of the Empire/Northeast System, and 35 to 45 percent of that of the Southeast/Northeast System, services markets anchored in Upstate New York and in Virginia and North Carolina, respectively. Second, the per-mile construction costs for New

HSR and Maglev in Upstate New York and south of Washington are less than the equivalent costs in the Northeast Corridor alone.

Table Chapter 8 -4
Results for Integral Systems: Empire/Northeast and Southeast/Northeast

	Empire/Northeast System		Southeast/Northeast System	
HSGT in 2020:	**New HSR**	**Maglev**	**New HSR**	**Maglev**
Route-miles	880	878	862	861
Line-haul travel time, hours, New York-Buffalo	3.3	2.4		
Line-haul travel time, hours, Charlotte-Washington			3.0	2.1
Trains per day in each direction, New York-Buffalo	50	47		
Trains per day in each direction, Charlotte-Washington			53	65
Average fare per passenger-mile (dollars)	0.309	0.350	0.303	0.327
Passengers, Millions of Trips (2020)	32.6	33.9	32.5	36.5
Passenger-Miles, Millions (2020)	6,885	7,448	7,322	9,152
Average trip length (miles)	211	219	225	251
Percent of air traffic diverted	24.5%	31.8%	25.1%	38.8%
Percent of intercity auto traffic diverted	2.6%	2.6%	2.5%	3.2%
Projection Results (Dollar Amounts are Present Values in Millions for the Period 2000-2040)				
Surplus after continuing investments	**$10,530**	**$15,059**	**$11,576**	**$17,818**
Total benefits:	**$35,643**	**$42,219**	**$37,665**	**$49,920**
Benefits to HSGT users:				
System revenues	$18,129	$22,133	$18,782	$25,205
Users' consumer surplus	$12,479	$14,352	$13,045	$17,236
Total benefits to HSGT users	$30,609	$36,485	$31,826	$42,441
Benefits to the public at large:	$5,034	$5,735	$5,839	$7,479
Total costs:	**$37,339**	**$40,443**	**$33,197**	**$39,836**
Components of total costs:				
Initial investment	$29,739	$33,369	$25,991	$32,448
O&M expense	$6,832	$6,523	$6,531	$6,856
Continuing investments	$767	$552	$675	$531
Incidence of total costs:				
Costs borne by users	$18,129	$22,133	$18,782	$25,205
Publicly-borne costs	$19,210	$18,310	$14,415	$14,630
Total benefits less total costs	**($1,696)**	**$1,776**	**$4,468**	**$10,085**
Benefits to HSGT users less costs borne by users	$12,479	$14,352	$13,045	$17,236
Benefits to the public at large less publicly-borne costs	($14,175)	($12,576)	($8,576)	($7,151)
Ratio of total benefits to total costs	**1.0**	**1.0**	**1.1**	**1.3**
Ratio of benefits to HSGT users, to costs borne by users	1.7	1.6	1.7	1.7
Ratio of benefits to the public at large, to publicly-borne costs	0.3	0.3	0.4	0.5
Does this case meet the threshold tests for "partnership potential"?	YES	YES	YES	YES

In order to analyze the performance and requirements of the Empire/Northeast and Southeast/Northeast Systems, it is essential to divide each of them into two portions: (1) the Northeast Corridor "alone," and (2) the Empire or Southeast Corridor "proper." The latter portion approximates the passenger-miles, revenue, expenses, investment requirements, and other factors that can be fairly attributed to the Empire or Southeast Corridor as part of the integral system with the Northeast Corridor. The attribution of values to the Empire or Southeast Corridor proper, within the respective integral systems, is performed as follows (using passenger-miles in the Empire Corridor for example):

Passenger-miles attributed to the "Empire Corridor proper" EQUALS:
Passenger-miles projected for the Empire/Northeast System
LESS: Passenger-miles projected for the Northeast Corridor alone (as per Chapter 7).

Other attribution methods are possible, and would need to be explored (see footnote 3).

Synthesizing the effects of the traffic synergies and construction cost differentials, Figure Chapter 8 -7 shows the annual passenger-miles per dollar of initial investment in the Northeast Corridor alone versus the Empire and Southeast Corridors proper. For both New HSR and Maglev, the Empire Corridor generates values only slightly below those of the Northeast Corridor itself, while the Southeast Corridor generates much heavier traffic than the Northeast Corridor per investment dollar.

Figure Chapter 8 -7
Annual Passenger-Miles Per Dollar of Initial Investment

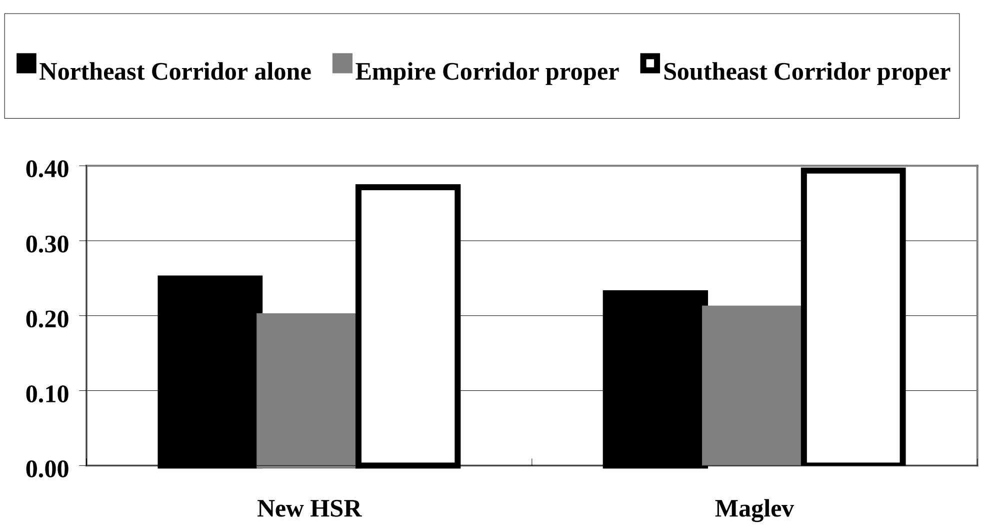
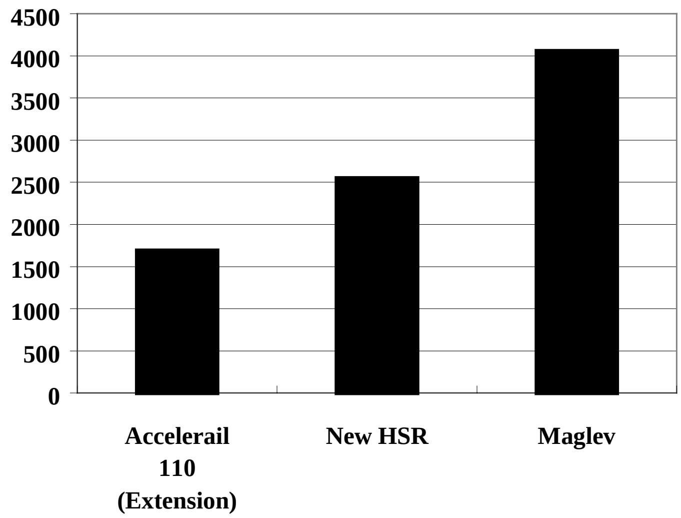


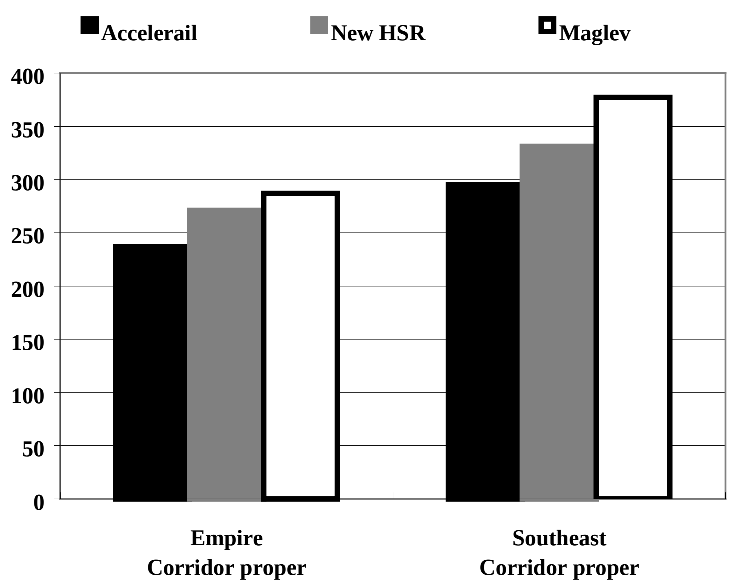
Figure Chapter 8 -8
Passenger-Miles (in Millions)
Attributed to Southeast Corridor Proper



The especially high traffic payoff for New HSR and Maglev in the Southeast Corridor echoes the "California effect" apparent in the traffic results for California North/South; against the backdrop of a very large, long-distance travel demand (reflecting geographic factors described on pages 8-3 ff.), the trip-time performance of New HSR and especially Maglev competes very strongly with air and diverts sizable numbers of passengers for longer and more profitable trips. (See Figure Chapter 8 -8.)

While the opportunities for long-haul cross-traffic are more limited in the Empire than in the Southeast Corridor, the average trip length in both corridors proper grows as travel time decreases (Figure Chapter 8 -9).

Figure Chapter 8 -9
Average Trip Lengths for Traffic Attributed to
Empire and Southeast Corridors Proper



"HYBRID" CORRIDORS

For the sake of simplicity and consistency, the study ordinarily assumed a single technology for each case.[11] (See Chapter 3, especially Table 3-3.) Since the suitability of a technology modulates with traffic density, and since corridors frequently show patronage levels that vary greatly by segment, a single-technology restriction could produce suboptimal results in a detailed State study of a particular corridor. To demonstrate the potential effects of mixing and matching technologies, the California North/South corridor was analyzed with New HSR north, and Accelerail 125E south, of Los Angeles. (Because the two technologies are fully compatible, no passenger or locomotive transfers at Los Angeles would be necessary.)

The decline in performance at the southern end of the corridor manifests itself in lower traffic, revenues, and operating surpluses for the hybrid versus New HSR:

Table Chapter 8 -5
Comparative Results of Hybrid Option in California North/South Corridor
(Dollar Amounts are in Millions)

Annual Measures	**Accelerail 125E**	**Hybrid [125E/200]**	**New HSR [200 mph]**	**Maglev [300 mph]**
Trip-time, hours, Los Angeles-San Francisco[12]	5.3	3.6	3.2	2.1
Passenger-Miles, Million	2,116	4,314	4,743	5,888
Revenue	$367	$723	$791	$1,167
Operating and maintenance expense	$223	$386	$394	$389
Operating surplus	$144	$337	$397	$778
Life-Cycle Measures (All amounts are Present Values, as of the Year 2000, of cash inflows/outflows over 40 years)				
Surplus after continuing investments	$864	$2,055	$2,489	$5,584
Initial Investment, Total	$8,948	$12,564	$15,792	$23,430
Percent of initial investment covered by surplus after continuing investments	9.7%	**16.4%**	15.8%	23.8%
Ratio of Total Benefits to Total Costs	1.0	**1.3**	1.2	1.1
Ratio of Benefits to HSGT Users, to Costs Borne by Users	2.3	**2.2**	2.2	2.1
Ratio of Benefits to the Public at Large, to Publicly-Borne Costs	0.6	**0.8**	0.7	0.6

[11] The exceptions were the non-electric Accelerail options in the Southeast and Empire corridors, which were matched with Accelerail 150E in the already-electrified Northeast Corridor.
[12] Note that the California North/South corridor in this report extends the full distance from the San Francisco Bay Area through Los Angeles to San Diego. The trip times reported in this table include a portion of trackage in the Los Angeles region that, under the "hybrid" case, is upgraded to Accelerail 125E instead of New HSR.

However, over time, these traffic, revenue, and surplus impacts amount to little in comparison with the significant saving in initial investment. Because a higher proportion of benefits than of costs is retained in stepping down from a “pure” New HSR technology to the hybrid, the latter offers somewhat better projections for both commercial and benefit/cost measures. Thus, Table Chapter 8 -5 clearly demonstrates that the more subtle approach—letting the investment follow the revenue, rather than dictating a uniform service level throughout each corridor—may enhance the outcome of the planning process.[13]

The California hybrid case demonstrates how States can fine-tune their corridor studies to maximize the cost-effectiveness of HSGT investments. In addition to mixing and matching technologies, State planners have many other opportunities, far beyond the scope of the present report, for profitably diversifying corridor options. For example:

- **Staging** of options—the gradual implementation of more and more ambitious HSGT solutions, over the 40-year planning period and possibly beyond—merits intensive scrutiny. For example, opportunities may exist for routes to be developed for Accelerail 90 or 110 service, then upgraded to 125F, then purchased from the underlying railroad and converted to 150E, or even (with extensive realignment depending on the locale) to New HSR. As a further hypothetical illustration of this principle: in the Northeast Corridor of the 21st century, burgeoning Accelerail 150E and commuter traffic, coupled with capacity constraints in the tunnels to Manhattan and in Pennsylvania Station, may ultimately require a partnership to build a parallel or significantly expanded route through New York City for both local and intercity traffic. If designed with vision, such a bypass or augmentation could ultimately become the kernel for a New HSR route for the Northeast Corridor, which could, over the course of many decades, gradually extend north and south from New York to supplant portions of the existing alignment.
- **Routing** questions will likewise undergo serious scrutiny at the State and local level, and rightfully so. The need to concentrate traffic on minimal route-mileage—evidenced in the Chicago Hub Network,[14] Texas, and the Southeast Corridor[15]—dictates careful attention to the economic theory of railway location. This may involve multi-State discussions of routing alternatives and extension possibilities.

[13] This has clearly been the approach overseas. In France, for example, a pre-existing electrified network extended the market reach of the Paris—Lyons TGV and helped to make the initial project feasible.
[14] Where the whole was much greater than the sum of its parts due to traffic synergy.
[15] Where incremental traffic over the Northeast Corridor provided a basis for the favorable projections described above.

For analytical convenience, this report adopted existing Amtrak routings wherever possible. This assumption, however, yielded Accelerail route-mileage almost twice as long as that of New HSR and Maglev in at least one corridor (Texas) where other realistic opportunities may exist. California presents routing conundrums that only the State can resolve: for example, the existing through passenger line (via the Coast) serves completely different and less populous intermediate markets than the Central Valley route, while the latter would require a new alignment over the Tehachapi Mountains to achieve truly expeditious service.

In selecting alignments that would demonstrate the full spectrum of graded technological options, this study made no attempt to consider all the theoretical possibilities.

- **Combinations of the above.** In many instances, a comprehensive corridor analysis would need to address mixing and matching, staging, and routing questions simultaneously.

SENSITIVITY ANALYSES

This section describes sensitivity excursions that assessed the effects of changes in assumptions pertaining to two areas—operating and maintenance expenses, and airline fares in competition with HSGT.

Operating and Maintenance Expenses

As incorporated in this report, HSGT operating expenses represent an improvement over those experienced by Amtrak prior to its recent restructuring. For the Texas Triangle, Florida, and California corridors, Table Chapter 8 -6 shows the ratio of projected HSGT unit expenses to 1993 Amtrak cost levels. In all three illustrations, unit expenses are on the order of 60 percent of Amtrak long-term avoidable costs (less for the high-volume California options).

Thus, the question naturally arises: how would adoption of expense levels more akin[16] to Amtrak's affect the results of this study?

To answer this question, a set of alternate assumptions was applied to three test cases, i.e.:

- Chicago—Detroit 125F;

[16] It would be inappropriate to impose a cost structure **identical** to that of Amtrak on the HSGT cases in this study. For these cases, the significant capital investment (in such support facilities as vehicle maintenance shops), the modern equipment and infrastructure, the high volume of travel, and the frequent train service would make for an operation—and a cost structure—fundamentally different from Amtrak's.

- Chicago Hub 110; and
- California North/South, New HSR.

Table Chapter 8 -6
Unit Operating Expenses[17] for HSGT as Percent of Amtrak Long-Term Avoidable Unit Expenses in 1993[18]

	90	110	125F	125E	150F	150E	New HSR	Maglev
California North/South	79%	59%	62%	64%	57%	58%	50%	40%
Florida	71%	69%	66%	71%			79%	78%
Texas Triangle	63%	65%	60%	67%	60%	71%	65%	66%

These assumptions reflected changes from the normative operating expenses, as described in Chapter 5, in areas typified by the following:

- Less use of automated ticket dispensing;
- Restoration of on-train ticket control;
- Reintroduction of checked baggage service; and
- Recognition of food-service deficits.

With such changes in assumption, annual operating expenses for the test cases would exceed the normative projections by approximately 25 percent. (See Table Chapter 8 -7.) All the cases would see a marked decrease in the ratio of operating surpluses to initial investment. The benefit/cost effect of these annual expense increases depends on the relative importance of O&M in the total life-cycle costs of the case—largely a function of the technology. The capital-intensive New HSR case in California, therefore, shows relatively little change in the benefit/cost ratios as a result of the expense hikes. By contrast, the Chicago Hub Network Accelerail 110 case—in which operating expenses normatively

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[17] Operating expenses per passenger mile.

[18] The ratio for each HSGT option is to Amtrak per-passenger-mile long-term avoidable costs as follows:

Expense per passenger-mile (Based on Year 1993)	Source on Amtrak (1993 data)	Applied as denominator in ratios for—
16.5 cents	Combined Metroliner and Northeast Corridor Boston—Washington conventional services	HSGT corridors with 900 million passenger-miles or more
19 cents	Chicago—Detroit; New York—Albany—Buffalo	HSGT corridors with less than 900 million passenger-miles, but with average trip lengths over 100 miles
22 cents	Los Angeles—San Diego	HSGT options with less than 900 million passenger-miles and average trip lengths less than 100 miles

make up 42 percent of the total costs—shows a ten percent disimprovement in its total benefit/cost ratio, and a 24 percent reduction in its public benefit/cost ratio.

In this sensitivity test, none of the sample cases loses its partnership potential. Operating surpluses persist, albeit in smaller quantities, and total benefits still exceed total costs. Still, the projects are significantly less capable of financing themselves, the benefit/cost ratios are diminished, and the partnership potential, in practical terms, suffers. For this reason, the attainment of operating economies, just as well as the maximization of net revenues, will remain a guiding principle of HSGT planning and management.

Table Chapter 8 -7
Results of Sensitivity Analysis—Higher Operating Expense Assumptions

	Chicago-Detroit [125 mph fossil]			**Chicago Hub Network [110 mph fossil]**			**California North/South New HSR [200 mph]**		
[Dollar amounts are in millions except where noted]	Norma -tive	Sensi -tivity	Sensitivity higher (lower) than Normative, Percent[19]	Norma -tive	Sensi -tivity	Sensitivity higher (lower) than Normative, Percent[19]	Norma -tive	Sensi -tivity	Sensitivity higher (lower) than Normative, Percent[19]
Annual Measures, Year 2020									
Passenger-Miles, Million	493.84	493.84		1,313.19	1,313.19		4,742.19	4,742.19	
Revenue	87.7	87.7		227.0	227.0		791.3	791.3	
Operating and maintenance expense	56.7	71.2	26%	137.8	172.8	25%	394.4	486.7	23%
O&M expense per passenger-mile (dollars)	0.115	0.144	26%	0.105	0.132	25%	0.083	0.103	23%
Amtrak unit expense[20] (dollars)	0.19	0.19		0.165	0.165		0.165	0.165	
O&M expense per passenger-mile as percent of Amtrak unit expense	60%	76%	26%	64%	80%	25%	50%	62%	23%
Operating surplus	31.1	16.5	(47%)	89.2	54.2	(39%)	396.9	304.6	(23%)
Operating surplus per passenger-mile (dollars)	0.063	0.033	(47%)	0.068	0.041	(39%)	0.084	0.064	(23%)
Life-Cycle Measures (All amounts are Present Values, as of the Year 2000, of cash inflows/outflows over 40 years)									
Surplus after continuing investments	189.2	65.0	(66%)	559.9	264.2	(53%)	2,489.4	1,755.5	(29%)
Initial Investment, Total	1,150.6	1,150.5		1,486.8	1,486.5		15,792.0	15,792.0	
Percent of Initial Investment Covered by Surplus After Continuing Investments	16%	6%	(66%)	38%	18%	(53%)	16%	11%	(29%)
O&M Expense as Percent of Total Costs	29%	36%	24%	42%	53%	26%	17%	21%	22%
Ratio of Total Benefits to Total Costs	1.5	1.4	(6%)	2.5	2.2	(10%)	1.2	1.1	(4%)
Ratio of Benefits to the Public at Large, to Publicly-Borne Costs	1.1	1.0	(11%)	2.8	2.1	(24%)	0.7	0.7	(5%)

[19] Where ratios and percentages are concerned, this column shows a ratio of ratios rather than a percentage-point spread. Slight discrepancies are due to rounding.
[20] Long-term avoidable cost per passenger-mile, for comparable operations as discussed in Footnote 18.

Low-Fare Air Service

In markets not served by low-cost carriers in 1993, baseline air fares for this study are probably higher than they would be if one or more low-cost carriers had been involved. Since low-cost carriers may expand to additional markets, it is possible that HSGT in some corridors would face lower prices on the part of airlines than those characterized in the normative analyses for this study. For this reason, the sensitivity of HSGT traffic projections to the introduction of low-fare air services was examined. This section discusses the extent of low-fare air service in the illustrative corridors and estimates the effect of lower air fares in selected markets.

Extent of Low-Fare Air Service

Table Chapter 8 -8 lists many of the major air markets[21] in the HSGT corridors and identifies those which had "low-fare air service" in 1993 (the year forming the basis for the analysis) and in March 1996, when this portion of the analysis was completed. Only major markets served with jet aircraft are shown. Markets served predominantly by regional carriers with turboprop aircraft are not included since these markets are not prime candidates for the successful introduction of low fares.

No specific definition of "low-fare" service exists. The fare yields for the highest fare carriers in one market might, if offered in another market, be well below the existing fare yields. Therefore, identifying which markets were served by "low-fare carriers" involved both qualitative and quantitative factors. A list of low-cost carriers likely to offer low fares was developed on the basis of news articles, advertisements, and limited data. Quantitative factors were then used to evaluate the presence of low-cost carriers and low fare levels in specific markets, recognizing that low-cost carriers might not offer low fares in all markets they serve, and that airlines with more traditional service, costs, and fares might offer low fares in selected markets. The quantitative factors used in determining whether a service is considered low-fare for this analysis are:

- At least five jet round trips daily by a single carrier (in the case of Miami-Tampa a combination of two carriers was relied upon to reach that threshold). This criterion avoids classifying a market as low-fare if the low-cost airline has only a minimal presence in a market;

[21] In some cases airport pairs rather than city pairs are shown.

Table Chapter 8 -8
Illustrative HSGT Corridors: Low-Fare Air Service in Major Air Markets[22]

[See footnote 23 below for carrier designation codes.]

Corridor and Market	***1993***	***1996***
California North/South		
Los Angeles-San Francisco		UA
Los Angeles-Oakland	WN	WN/UA
Los Angeles-San Jose	WN/QQ	WN/QQ
San Diego-San Francisco	WN	WN\UA
San Diego-Oakland	WN	WN
Burbank-San Francisco	QQ	UA
Burbank-Oakland	WN	WN
Burbank-San Jose	WN	WN
San Jose -Orange County		WN/QQ
Ontario-San Francisco		UA
Ontario-San Jose	WN	WN
Ontario-Oakland	WN	WN
San Diego-San Jose	QQ	WN\QQ
California South		
San Diego-Los Angeles		
Chicago Hub Network		
Chicago-Detroit	WN	WN
Chicago-St. Louis	WN	WN
Detroit-St. Louis	WN	WN
Detroit-Milwaukee		

(Table Chapter 8 -8 continues on the next page.)

[22] 1993 schedules based on North American Edition, Official Airline Guide, December 1993; 1996 schedules based on North American Edition, Official Airline Guide, March 1996

[23] Carrier designation codes are as follows:

CO	Continental "Lite"
J7	Valujet Airlines
QQ	Reno Air
TZ	American Transair
UA	Shuttle by United
WN	Southwest Airlines
WV	Air South

Note: America West is also a low-cost /low-fare carrier, at least is some markets, but did not offer service in any of the markets listed in Table Chapter 8 -8.

(Table Chapter 8 -8 continued . . .)

Corridor and Market	***1993***	***1996***
Florida		
Tampa-Miami		WV/TZ
Fort Lauderdale-Tampa	CO	WN
Miami-Orlando		
Northeast Corridor		
New York-Boston		
New York-Washington		
New York-Baltimore	CO	
Boston-Baltimore		
Boston-Philadelphia		
Providence-New York		
Providence-Washington		
Pacific Northwest		
Seattle-Portland		
Vancouver-Seattle		
Vancouver-Portland		
Eugene-Seattle		
Texas Triangle		
Dallas-Houston	WN	WN
Houston-San Antonio	WN	WN
Dallas-San Antonio	WN	WN
Austin-Dallas	WN	WN
Austin-Houston	WN	WN
Empire Corridor		
New York-Buffalo	CO	
New York-Rochester		
New York-Syracuse		
Southeast Corridor		
New York-Raleigh		
Philadelphia-Raleigh		
Washington/Baltimore-Raleigh		J7
New York-Greensboro	CO	CO
Philadelphia-Greensboro		
Washington/Baltimore-Greensboro	CO	
New York-Charlotte		
Philadelphia-Charlotte		
Washington/Baltimore-Charlotte		

- Fares well below those in other similar stage length jet markets in the same area of the country on a continuing basis (not just during "fare wars"); and
- Generally one way, unrestricted ("walk-up") fares are available at no higher than half the round trip, advance purchase excursion fares offered by the major non-discount carriers.

Table Chapter 8 -8 shows each of the qualifying air markets. The primary discount carrier (or carriers) is shown in each market for December 1993 and for March 1996. In most cases, other carriers serving the market can be assumed to have matched, at least on a limited availability basis, the offerings of the low-fare air carrier. If no carrier code is shown in a box on the chart, there was no low-fare carrier operating in that market.

Table Chapter 8 -8 shows that, as of 1993, low-fare air carriers had established a significant presence in the California North/South, Chicago Hub Network, Chicago—Detroit, Chicago—St. Louis, and Texas Triangle corridors, and had entered selected markets in the Northeast, Empire, and Southeast Corridors. No low-fare service existed in the California South, Florida, and Pacific Northwest corridors. Thus, the analytical base for this study already includes extensive, although by no means ubiquitous, low-fare operations.

The situation as of March 1996 suggests that considerable fluidity exists in the entry and exit of low-fare carriers in city-pair and airport-pair markets. Although some markets enjoy recently added low-fare service (for example, additional airport pairs in the high-volume Bay Area—Los Angeles market), others—in the Northeast and Empire Corridors, for instance—have seen low-fare service disappear.

Through the 1990s, the absence of low-fare service in the California South and Pacific Northwest corridors, and its paucity in the Northeast Corridor, suggest that such site-specific factors as relatively short average trip lengths and high operating costs may discourage the introduction of low-fare air service, irrespective of the presence of HSGT. Many factors, however, enter into entrepreneurs' decisions to invest in new aviation services,[24] and into established airlines' pricing policies; thus, HSGT has no guaranteed immunity from airline price competition.

Estimate of Effects of Lower Air Fares

Since Florida lacked significant intrastate service by discount airlines in 1993, it provided a useful locale for a sensitivity analysis.[25] The demand model was applied to two

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[24] For example, since the 1960s and 1970s, low-fare air service has come and gone in some important Northeast Corridor markets and in San Diego—Los Angeles.

[25] By no means does the selection of these city-pairs, for the purpose of this hypothetical sensitivity check, imply that these markets will be consistently suitable for low-fare air service during the planning period (2000—2040). The distances are relatively short and detailed studies of, and experience with, volume,

city-pairs: Miami—Orlando (189 air-miles) and Miami—Tampa (201 air-miles). Only one change was made: air fares were lowered by 30 percent from their 1993 levels. All other factors were held constant, including HSGT fares and the market sizes of auto and of the hypothetical low-fare air service in the absence of HSGT.

The results, depicted in Table Chapter 8 -9, suggest that a 30 percent reduction in air fares would reduce diversion rates from air[26] to HSGT by about 24 to 33 percent and total HSGT traffic in these markets by about 10 to 24 percent.

Table Chapter 8 -9
Estimated Effect of Lower Air Fares on HSGT Traffic Volumes in Two City-Pairs
(New HSR Example—Florida Corridor)

	Market	
	Miami—Orlando	**Miami—Tampa**
(1) Percent reduction in air fare	30%	30%
(2) Percent reduction in diversions from air[26] to HSGT	24%	33%
(3) Net reduction in total HSGT traffic volumes	10%	24%
(4) Reduction in HSGT traffic volumes as percent of reduction in diversions from air to HSGT [= (3)/(2)]	42%	73%

The table reveals that for the two markets studied, and with all other factors held constant, a 30 percent reduction in air fare results in a roughly equivalent drop in projected diversions from air[26] to HSGT. However, since HSGT attracts its traffic base from sources other than air, total HSGT traffic volumes fall less markedly than air-sourced HSGT traffic alone. The degree of mitigation varies between the two markets: whereas total HSGT traffic declines by only ten percent in Miami—Orlando, it falls by 24 percent in Miami—Tampa. (See line (4) in Table Chapter 8 -9.) Clearly, if the susceptibility of HSGT to airline price competition can change so much from market to market in a single corridor, it can exhibit even more variation among different corridors. In evaluating HSGT options on a site-specific basis, therefore, States and HSGT entities may wish to conduct similar sensitivity tests on key markets with careful attention to localized factors. Such detailed analysis would need to consider a number of additional phenomena that do not enter into Table Chapter 8 -9. These complicating factors include but are not limited to:

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capacity, and other important operating, marketing, and financing issues would be prerequisite to an airline's conduct of such service during that period.

[26] That is, diversion from "origin/destination" air traffic only. This traffic consists of air trips the true endpoints of which both lie within the HSGT corridor.

- Likelihood of actual entry of low-fare carriers into the corridor's constituent markets (i.e., their prospective investment requirements and results of operations given, e.g., the operating performance and costs at the specific airports involved);
- Long-term effects on the air traffic base in the constituent markets—this involves such factors as induced demand and attracted traffic from competing markets;
- Long-term effects of the presence of low-fare air carriers on the auto traffic base and (where important) on conventional rail and bus ridership; and
- The likely response of an HSGT operator to the entry of low-fare air competition, in terms of pricing, service design, and other factors; and the effects on air and auto diversion of that HSGT response.

CHAPTER 9
CONCLUSIONS

The study results suggest that States should consider HSGT along with other options for improving intercity passenger transportation.

SYSTEM REQUIREMENTS AND PERFORMANCE

HSGT can cost from less than $2 million to $50 million per route-mile to build. The less expensive options—upgraded existing railroads with 90-150 mph maximum speeds—can, in some corridors, represent affordable travel improvements that would expand the range of transportation choices. With top speeds up to 200-300 mph, the costlier options can provide very fast, reliable, and comfortable transportation service, as in a Maglev timing of just over an hour between midtown Manhattan and downtown Boston.

In the design and application of all HSGT technologies, the Department regards safety as paramount. Evolving safety research and regulation could thus influence the capital cost structure for Accelerail, New HSR, and Maglev. Similarly, research and development in other facets of railroad and Maglev system design could reduce the investment levels for HSGT technologies. As the effects of these regulatory advances and technology development efforts become known, they will enter at the State level into the conceptual and detailed design of specific HSGT infrastructure and equipment investments.

HSGT could develop appreciable ridership. For example, by the year 2020 in the most heavily trafficked corridors (California North/South and the Northeast Corridor), New HSR and Maglev could exceed by as much as a factor of four Amtrak's current Northeast Corridor travel volumes. Likewise, Accelerail in California, the Chicago Hub Network, and Texas could approach or exceed existing Northeast Corridor patronage levels by 2020.

Because HSGT is capital-intensive, requiring a significant fixed investment to connect specific city-pairs, its success calls for the highest possible concentration of traffic and revenue over as few route-miles as possible, so as to raise travel volumes and lower unit costs. The study results bear out this fundamental dictum of HSGT planning: the Chicago Hub Network is greater than its parts, in sum or individually, due to more intensive and efficient use of the route structure[1]; in Texas, New HSR performs much better than the less-costly but twice-as-lengthy Accelerail 150; and the Southeast and Empire Corridor

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[1] For example, the Chicago Hub Network is projected to generate traffic levels that are one third to one half again as high as the sum of the individual corridors between Chicago and Detroit, Milwaukee, and St. Louis. Furthermore, the Chicago Hub Accelerail 110 case would cover about two-fifths of its initial investment requirement from operating surpluses—double the coverage in the Detroit and St. Louis corridors considered separately.

projections profit from more intensive use of the Northeast Corridor.[2] Thus route alignment, networking, and extension options merit careful consideration in detailed corridor studies.

In no corridor is HSGT projected to be commercially feasible, i.e., cover both its capital and operating costs. However, in most of the illustrative cases, HSGT is projected to function on a self-sustaining basis—independent of public subsidies—once the initial investment is in place and paid for. This finding assumes the cooperation of the freight railroads (for Accelerail cases primarily), and the HSGT entity's ability to achieve a more efficient operation than that which characterized Amtrak prior to its recent restructuring.

Beyond covering future operating and maintenance expenses and continuing investment needs, revenues in most of the illustrative cases could cover a portion of the initial investment. For most corridors, the percentage of the investment that can be so covered peaks with the Accelerail 110 option. Still, cases across the technological spectrum show promise of financing, from operations, noticeable portions (one fifth to one half) of their initial capital costs. In this regard, Accelerail 90 in California South, and New High-Speed Rail and Maglev in the Northeast Corridor, show the best performance: their surpluses are projected to cover, respectively, more than two-fifths, two-fifths, and one-half of their initial investment costs at the normative discount rates applied in this report.[3] Even higher coverage rates characterize the projections for Accelerail in the Southeast and Empire extensions of the Northeast Corridor, as described in Chapter 8.

Although the projections of system performance do not meet the traditional private-sector criterion for "commercial feasibility,"[4] they may provide a basis for private/public partnerships depending on the size of the initial investment required, detailed cash flow and other analyses, the financing capacities of the prospective partners, and the impetus afforded the partners by each project's perceived benefits and costs.

COMPARISON OF BENEFITS AND COSTS

Commercial feasibility in the traditional sense may provide too narrow a perspective on the worth of HSGT. Thus, in addition to demonstrating operating surpluses, an HSGT case is deemed to have partnership potential only if its total benefits also exceed its total costs. Moreover, in performing definitive feasibility studies of HSGT systems, policy makers and the public may regard it as essential to compare not just total benefits with total costs, but also the benefits and costs accruing to the public at large. The report, therefore,

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[2] Further detailed studies would be necessary to confirm the applicability of this principle in specific locations.
[3] See Figure 7-24.
[4] The sole possible exception is Accelerail 110 in the Southeast Corridor, for reasons explained in Chapter 8. Much further examination would be required to verify preliminary suggestions that such an extension might be self-financing when its effects on Northeast Corridor operating economics are fully recognized.

broadens the evaluation of HSGT by comparing total benefits with total costs, and benefits to the public at large with publicly-borne costs.

HSGT's total benefits exceed total costs in most of the illustrative cases. Each HSGT technology would have one or more corridors that provide a favorable ratio of total benefits to total costs: New HSR, for example, is projected to have partnership potential[5] in four of nine applicable illustrative corridors,[6] and Maglev in two of nine. On the basis of total costs and benefits, each illustrative corridor would have one or more HSGT technologies that would meet the threshold conditions for partnership potential.[7] The more heavily traveled corridors would generally show partnership potential over a broader spectrum of technologies.

HSGT's projected benefits to the public at large are less than its publicly-borne costs in some three-quarters of the illustrative cases. These shortfalls demonstrate the extent to which HSGT may be regarded as providing, in effect, for the subsidization of HSGT system users. Publicly-borne costs are projected to exceed benefits to the public at large in all corridors for Maglev, New HSR, and Accelerail 150. Benefits to the public at large consistently exceed costs only for Accelerail 90 and 110. However, cases in which public benefits do not exceed public costs need not be ruled out for consideration by States or private concerns. In such cases, prospective transfer effects, mobility concerns, and environmental factors may justify further consideration, even though such impacts did not enter into the benefit/cost calculation for this analysis.[8]

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[5] See Chapter 3.

[6] That is, corridors other than the extensions to the Northeast Corridor analyzed in Chapter 8.

[7] As defined in this report, "partnership potential" is the apparent capacity of an HSGT corridor to draw the private and public sectors together in planning, negotiations, and, conceivably, project implementation. To exhibit partnership potential, the projections for an HSGT technology in a particular corridor must satisfy at least the following two conditions: First, private enterprise must be able to run the corridor—once built and paid for—as a completely self-sustaining entity; in other words, the case must generate a projected surplus after continuing investments. Second, the total benefits of an HSGT corridor must equal or exceed its total costs. This report uses "partnership potential" as an indicator of the aggregate financial and economic impacts of HSGT alternatives in a set of illustrative corridors. Detailed State studies of individual corridors would benefit from additional evaluation measures as well as site-specific investigations and data. Thus, while "partnership potential" may offer useful insights in assessing the likelihood of HSGT development by State and local governments and their private partners, it does not constitute an express or implied criterion for Federal approval or funding. For further particulars on "partnership potential," the reader is referred to Chapters 3 and 6.

[8] See Chapter 6.

In a given corridor, the less expensive Accelerail technologies, relying on upgraded existing rail lines and freight railroad cooperation, could typically provide higher ratios of benefits to costs (both in total and for the public) than New HSR and Maglev. Accelerail's potential for HSGT at a modest initial investment cost validates the Department's Next-Generation High-Speed Rail technology development program—which supports use of existing railroads—and confirms several States' decisions to implement Accelerail options.

IMPORTANCE OF PARTNERSHIPS AND STATE ROLES

Successful private/public partnerships are essential to the construction and implementation of all HSGT systems. While necessarily varying among corridors and technologies, the potential for such partnerships will be strongest where self-sustaining operations can attract a private HSGT entity, where the benefits provide the State with a convincing rationale for the public investment, and where a State regards HSGT as a preferred approach to enhancing intercity travel mobility in an intermodal setting.

The States have specialized knowledge of local conditions and priorities, and the very nature of corridor planning also calls for detailed consideration of a full range of transport alternatives from a State and local perspective. Where public policy considerations dictate, States may also wish to pursue an examination of the incidence of benefits and costs in conjunction with their detailed corridor studies.

GLOSSARY OF SELECTED TERMS AND ABBREVIATIONS

NOTE: These are general definitions applicable throughout the report. Special-purpose definitions, or necessary specifics, appear *ad locum.*

Term or abbreviation	Meaning
Air O/D	Air traffic that has both of its true endpoints within a single corridor. (I.e., both its **origin** and **destination** cities lie within the same corridor.) Contrasts with "Air Transfer."
Air Transfer	Air traffic that makes use of **flights** between endpoints contained within the same corridor, **but that has its origin and/or destination outside that corridor.** Example: A traveler journeying from Chicago to Portland, Oregon, switches in Seattle to a local flight to Portland. The **flight** is within the Pacific Northwest Corridor, but the **passenger** is categorized as air transfer traffic.
ancillary activities	Traditional by-product businesses of intercity passenger transport companies—e.g., parking, concessions, advertising, mail and express. (See Chapter 5.)
benefits to HSGT users	The value of HSGT to its users, as measured by the system revenues (the price users pay directly) plus the users' consumer surplus (for which they do not pay). (See Chapter 6.)
benefits to the public at large	For this report's purposes: the combined value of the reductions in airport and highway congestion, and emissions, projected for an HSGT case. (See Chapter 6.)
case	A particular technological option (e.g., Accelerail 90, Accelerail 125F, New HSR, Maglev) modeled in a particular corridor (California North/South, Chicago Hub Network, and so forth). (See Chapter 3.)
CMSA	Consolidated Metropolitan Statistical Area. This represents a consolidation of data for its constituent Primary Metropolitan Statistical Areas (PMSAs). For explanation, consult any recent edition of the *Statistical Abstract of the United States.* See also MSA.
continuing investments	All capital additions, replacements, and overhauls

Term or abbreviation	Meaning
	undertaken by the HSGT entity after the initiation of corridor service. Contrasts with "initial investment," which occurs prior to the initiation of corridor service.
costs borne by users	The portion of benefits to users for which they pay directly (i.e., system revenues).
Department, the	U.S. Department of Transportation
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
HSGT	High-speed ground transportation
HSGT entity	The private sector partner that would take full responsibility for operating and maintaining a corridor upon completion. The HSGT entity would also finance all continuing investments needed to preserve and expand the service after its initiation. (This is an assumption for analytical purposes; the HSGT partners would ultimately determine the nature of the HSGT entity, which could be a public authority or mixed private/public concern.)
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
Maglev	Magnetic levitation
MSA	Metropolitan Statistical Area. This is generally smaller and/or less complex than a CMSA and does not contain constituent PMSAs.
NEC	Northeast Corridor
NECIP	Northeast Corridor Improvement Project
NMI	National Maglev Initiative
NTIS	National Technical Information Service
O&M	Operating and maintenance [expenses]
offer	The sum total of the marketing attributes presented by a mode of transportation to the public: trip times, fares,

Term or abbreviation	Meaning
	frequencies, and the many facets of service quality.
"operating expense(s)"; "operating and maintenance expense(s)"; "O&M expense(s)"	In this report, all three terms mean the same thing.
operating surplus	System revenues less O&M expenses.
PMSA	Primary Metropolitan Statistical Area. A constituent part of a consolidated metropolitan statistical area (CMSA), which see.
publicly-borne costs	Total costs, less costs borne by users; in other words, total costs, less system revenues. (See Chapter 6.)
RPM	revenue passenger-miles
SEC	Southeast Corridor (for this report's purposes, defined as the corridor between Charlotte, N.C., and the Washington/Baltimore CMSA; and treated as an extension of the Northeast Corridor)
System revenues	Total revenues projected for an HSGT case; includes passenger transportation revenue from fares, plus income from ancillary activities.
tangent	A straight portion of track
total benefits	For this report's purposes: The combined value of benefits to the public at large, plus benefits to HSGT users, projected for a case. (See Chapter 6.)
total costs	Initial investment, plus O&M expenses, plus continuing investments. (See Chapters 5 and 6.)
unit expense	Operating expense per passenger-mile
unit margin	Revenue per passenger-mile less operating expense per passenger-mile (equates to operating surplus per passenger-mile).
VMT	vehicle-miles traveled

STATISTICAL SUPPLEMENT

Contents

Explanation of Line Items

The following is a line-by-line explanation of the contents of the Statistical Supplement. <u>Line reference numbers appear only in this "Explanation" for purposes of specifying formulas</u> and do not appear in the body of the Statistical Supplement. In the "Line Reference Number" column, the letter [h] means that the line is solely a heading and contains no amounts.[1]

Line Reference Number	Line Item	Description
1[h]	Physical, production, and traffic factors (traffic data is for the year 2020)	Heading. <u>Note that lines 4 through 53 relate to the year 2020, the midpoint year in the planning period.</u>
2	Route-miles	This value can be expected to differ among Accelerail, New HSR, and Maglev options, as routing differences are common. Within the Accelerail range, values will differ in California North/South because 90 and 110 use the coastal alignment, while 125 and 150 use the Central Valley. In all corridors, slight discrepancies among Accelerail options may reflect differences in realignments.
3	Trip-time, hours, Los Angeles-San Francisco *(example*	In most corridors, this is the trip time between the two <u>most</u>

[1] Line reference numbers 30, 54, and 76 are reserved and omitted from this listing.

Line Reference Number	Line Item	Description
	taken from California North/South)	distant stations in the city-pair mentioned; i.e., from the most northerly station in the San Francisco Consolidated Metropolitan Statistical Area (CMSA) to the most southerly station in the Los Angeles CMSA. In the Northeast Corridor only, specified trip times are from the vicinity of Penn Station, New York, to the vicinity of South Station, Boston.
4	Average train speed (mph)	= line 21 divided by line 27. Note: this is a system average speed and has nothing to do with the trip times quoted in line 3.
5	Average fare per passenger-mile (dollars)	= line 33 divided by line 8. Note: this is passenger transportation revenue (and not system revenue) divided by passenger-miles.
6	Trains per day in each direction	This is over the link specified in line 3.
7	Passengers, Millions of Trips (2020)	As is customary, "trips" are one-way trips. A traveler taking a round trip (e.g., from Chicago to Detroit and return) counts as two trips.
8	Passenger-Miles, Millions (2020)	
9	Average trip length (miles)	= line 8 divided by line 7.
10	Average trip length as % of route length	= line 9 divided by line 2.
11	HSGT traffic density per route-mile (millions of passenger-miles per route-mile)	= line 8 divided by line 2.
12	Percent of air traffic diverted	For air trips with both origin and destination within the corridor: the number of trips that would be diverted to HSGT divided by the number of air trips that would occur in the absence of HSGT.
13	Percent of intercity auto traffic diverted	The number of trips that would be diverted to HSGT divided by the number of auto trips that would occur in the absence of HSGT.
14[h]	Percent of HSGT traffic by source:	Heading. The following lines indicate the composition of the HSGT traffic in the year 2020. See Figure 7-11 for a graphic representation of the following percentages (for California North/South as an example). Percentages are based on "passengers" (i.e., trips).
15	Diverted from air	
16	Diverted from auto	
17	Diverted from conventional rail	
18	Diverted from bus	
19	Induced	Note: The induced traffic generally ranges from 7 to 9 percent of total HSGT traffic.
20[h]	Operating efficiency factors, 2020	Heading. The following are traditional statistics and derivatives used in the analysis of transportation operations.
21	Train-miles. millions	
22	Passenger-miles per train mile	= line 8 divided by line 21
23	Seat-miles, millions	
24	Load factor	= line 8 divided by line 23

Line Reference Number	Line Item	Description
25	Gross ton-miles, millions	
26	Passenger-miles per gross ton-mile	= line 8 divided by line 25
27	Train-hours, millions	
28	Passenger-miles per train hour	= line 8 divided by line 27
29	Operating ratio (O&M total expense/passenger transportation revenue)	= line 43 divided by line 33. Note that this derivative <u>excludes</u> ancillary activities and is intended as a measure of <u>passenger transportation operating performance</u> only.
31[h]	Operating results for 2020	Heading. Dollar amounts are in millions unless otherwise stated.
32[h]	Revenues:	Heading.
33	Passenger transportation revenue	This is the predominant revenue source.
34	Income from ancillary activities	This is net of associated expenses. See the "Ancillary Activities" section of Chapter 5.
35	System revenues	= line 33 plus line 34.
36	Percent of system revenues from ancillary activities	= line 34 divided by line 35. Normally equates to 2 to 5 percent.
37[h]	Operating and maintenance expenses:	Heading. See Chapter 5 for a discussion of the components of O&M expense.
38	Maintenance of way	
39	Maintenance of equipment	
40	Transportation	
41	Passenger traffic and services	
42	General and administrative	
43	Total O&M expense	= sum of lines 38 through 42.
44[h]	Per passenger-mile (dollars):	Heading. Equals each of lines 38 through 43, divided by line 8.
45	Maintenance of way	= line 38 divided by line 8.
46	Maintenance of equipment	= line 39 divided by line 8.
47	Transportation	= line 40 divided by line 8.
48	Passenger traffic and services	= line 41 divided by line 8.
49	General and administrative	= line 42 divided by line 8.
50	Total O&M expense	= line 43 divided by line 8.
51	Operating surplus	= line 35 minus line 43.
52	Operating surplus per passenger-mile (dollars)	= line 51 divided by line 8.
53	Year showing first operating surplus	Within the planning period 2000-2040, this is the first year in which line 51 is greater than zero. Most cases show a projected surplus in the first year.
55[h]	Life-Cycle Measures (All amounts are present values, as of the year 2000, of cash inflows/outflows between 2000 and 2040.)	Heading. <u>All the following lines reflect present values pertaining to the entire planning period. (For initial investments, the outflows are actually assumed to occur in the three years preceding 2000; see Chapter 4.)</u> Dollar amounts are in millions.
56[h]	Revenues:	Heading.

Line Reference Number	Line Item	Description
57	Passenger Transportation Revenues	Analogous to line 33.
58	Income from Ancillary Activities	Analogous to line 34.
59	System Revenues	= line 57 plus line 58.
60	Less: Total O&M expenses	Analogous to line 43.
61	Operating surplus	= line 59 minus line 60.
62	Less: Continuing investments	As described in Chapter 5, the continuing investments are all capital programs occurring after the inception of service.
63	Surplus after continuing investments	= line 61 minus line 62.
64[h]	Initial investment:	Heading.
65	Initial vehicle investment	
66	Initial infrastructure investment	
67	Initial investment for ancillary activities	
68	Initial investment, Total	= sum of lines 65 through 67.
69[h]	Percent of total initial investment pertaining to--	Heading. Equals each of lines 65 through 67, divided by line 68.
70	Vehicles	= line 65 divided by line 68.
71	Infrastructure	= line 66 divided by line 68.
72	Ancillary activities	= line 67 divided by line 68.
73	Total initial investment per route-mile	= line 68 divided by line 2. Note that this per-mile figure <u>includes</u> vehicles and ancillary investments.
74	Portion of initial investment that is <u>not</u> covered by surplus after continuing investments	= line 68 minus line 63. On the supposition that the present value of all surpluses (i.e., line 63) accrues to the governmental partners, this line represents the net public investment in the project. To the degree that less than all surpluses accrue to the governmental partners, the net public investment would be so much the greater.
75 77[h]	Percentage of initial investment covered by surplus after continuing investments Comparison of Benefits and Costs; Assessment of Partnership Potential	= line 63 divided by line 68. This is a key commercial measure since it approximates the maximum percentage of the project that might be self-financed. Heading.
78	Surplus after continuing investments	This is line 63, repeated here. <u>The existence of a surplus after continuing investment is the first of two tests for partnership potential</u> (see Chapter 3 and line 107 below).
79[h]	Total benefits:	Heading.
80[h]	Benefits to HSGT users:	Heading. See Chapter 6.
81	System revenues	These are the “benefits for which HSGT users pay directly.”
82	Users' consumer surplus	These are the benefits for which HSGT users <u>do not</u> pay directly.
83	Total benefits to HSGT users	= line 81 plus line 82.
84[h]	Benefits to the public at large:	Heading.

Line Reference Number	Line Item	Description
85[h]	Airport congestion delay savings	Heading.
86	Operation delays	These are the operational savings to airlines from the reduced airport congestion projected to be occasioned by HSGT.
87	Passenger delays	This is the value of air passengers' time saved due to projected reductions in airport congestion.
88	Total airport congestion delay savings	= line 86 plus line 87.
89	Highway delay savings	This is the value of reduced highway congestion projected to result from HSGT.
90	Emission savings	This is the value of reduced emissions projected to result from HSGT.
91	Total benefits to the public at large	= sum of lines 88 through 90.
92	Total benefits	= line 83 plus line 91. That is: the total benefits to users <u>and</u> the public at large.
93[h]	Total costs:	Heading. The following three lines show the constituents, by type, of total costs:
94	Initial investment	= line 68.
95	O&M expense	= line 60.
96	Continuing investments	= line 62.
97	Total costs	= sum of lines 94 through 96.
98[h]	Incidence of total costs:	Heading. The following lines distribute the total costs among the sources of funds: users at the farebox, versus the public at large.
99	Costs borne by users	This equals system revenues as shown in line 59. When total costs are greater than revenues—as is true with the cases projected in this report—then system revenues necessarily represent the portion of those total costs for which users pay.
100	Publicly-borne costs	= line 97 less line 99. That is, it is the total costs less the costs borne by users. It also equals line 74, which is another way of arriving at the same result.
101	Total benefits less total costs	= line 92 less line 97.
102	Benefits to HSGT users less costs borne by users	= line 83 less line 99.
103	Benefits to the public at large less publicly-borne costs	= line 91 less line 100.
104	Ratio of total benefits to total costs	= line 92 divided by line 97. <u>This ratio (calculated to one decimal place) must equal or exceed 1.0 to meet the second of two tests of partnership potential</u> (see Chapter 3 and line 107 below).
105	Ratio of benefits to HSGT users, to costs borne by users	= line 83 divided by line 99.
106	Ratio of benefits to the public at large, to publicly-borne costs	= line 91 divided by line 100.

Line Reference Number	Line Item	Description
107	Does this case meet the threshold tests for "partnership potential"?	If line 78, the surplus after continuing investments, is greater than zero; and if line104, the ratio of total benefits to total costs, is 1.0 or more; then this report deems the case to have “partnership potential” and a “YES” appears here. Otherwise, no “partnership potential” is found and a “NO” appears in the appropriate column.